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High Temperature Composite Analyzer (HITCAN) Demonstration Manual

Version 1.0

S.N. Singhal and J.J. Lackney
Sverdrup Technology, Inc.
Lewis Research Center Group
Brook Park, Ohio

and

P.L.N. Murthy
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio

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NASA

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ABSTRACT

This manual comprises a variety of demonstration cases for the HITCAN (HIgh Temperature Composite ANalyzer) code. HITCAN is a general purpose computer program for predicting nonlinear global structural and local stress-strain response of arbitrarily oriented, multilayered high temperature metal matrix composite structures. HITCAN is written in FORTRAN 77 computer language and has been configured and executed on the NASA Lewis Research Center CRAY XMP and YMP computers. Detailed description of all program variables and terms used in this manual may be found in the USER's MANUAL.

The demonstration manual includes various cases to illustrate the features and analysis capabilities of the HITCAN computer code. These cases include: 1) static analysis, 2) nonlinear quasi-static (incremental) analysis, 3) modal analysis, 4) buckling analysis, 5) fiber degradation effects, 6) fabrication-induced stresses for a variety of structures; namely, beam, plate, ring, shell, and built-up structures. A brief discussion of each demonstration case with the associated input data file is provided. Sample results taken from the actual computer output are also included.

CHAPTER 1

INTRODUCTION

This manual presents input data files for 13 sample problems demonstrating the static, buckling, modal, and quasi-static analysis capabilities of the high temperature composite analyzer code HITCAN. The quasi-static analysis means incremental nonlinear analysis where the material properties are updated at the end of each load step, based on a nonlinear multi-factor interaction model (Ref. 1). With continued enhancements, HITCAN is expected to be capable of handling a wide spectrum of analyses for high temperature metal matrix composite structures, all of which are not demonstrated in the present edition of this manual. Table I lists capabilities of HITCAN, showing the ones that have been demonstrated (Ref. 2) marked 'tested' in italic typeface. Each analysis capability is demonstrated for five generic types of structures, i.e. beam, plate, ring, curved panel, and a built-up structure. The sample problems include special code features such as fiber degradation and fabrication-induced stresses.

HITCAN can model structural components with solid as well as hollow geometrical shapes. The input data structure is different for solid versus hollow structures. All beam, plate, ring, and curved panel problems demonstrate modeling of solid structures and those for built-up structure demonstrate modeling of hollow structures.

The element library in the current version 1.0 of HITCAN includes plate, 3D solid, plane stress, and plane strain elements. The finite element code, MHOST, utilized in HITCAN also includes beam and axisymmetric elements. Further, MHOST is presently being updated to allow mixing of elements. All of these individual and mixed element capabilities will become functional in HITCAN in the future. The 13 problems presented in the present edition of this manual were modeled using the plate element. Demonstration problems for other element types of HITCAN will be added as they become available.

Although an effort is made to include all the information necessary for understanding the demonstration problems in the present manual, a line-by-line description of the input files is not provided. It is expected that the user has access to the HITCAN User's Manual (Ref. 3). The user's manual includes 2 sample problems with detailed explanation of input and output data structures.

The description of demonstration problems is provided in numerical order from 1 to 13. Figures showing geometry, boundary conditions, and loading, files showing the data structure, and a file showing selected portions of the output data structure are included with each problem. The detailed output files have been archived in NASA's VM computer system and can be retrieved, if necessary. The material property data files being similar for many problems, are given in Appendix 1. The HITCAN execution command files ("DEMOX NQS" and "DEMOY NQS" for the NASA LeRC CRAY XMP and YMP computers, respectively) are included in Appendix 2.

Table 1. - HITCAN Capabilities for Composite Materials

Type of Analysis ↓ / Type of Structure →	Beam	Plate	Ring	Curved Panel	Built-up Structure
Static	*tested*	*tested*	*tested*	*tested*	*tested*
Buckling (a)	*tested*	*tested*	*tested*	*tested*	*tested*
Load Stepping	*tested*	*tested*	*tested*	*tested*	*tested*
Modal (Natural Vibration Modes) (b)	*tested*	*tested*	*tested*	*tested*	*tested*
Time-domain	-	-	-	-	-
Loading					
Mechanical	*tested*	*tested*	*tested*	*tested*	*tested*
Thermal	*tested*	*tested*	*tested*	*tested*	*tested*
Cyclic	-	-	-	-	-
Impact	-	-	-	-	-
Constitutive Models (c)					
P = Constant	*tested*	*tested*	*tested*	*tested*	*tested*
$P = f(T)$ (temperature dependence)	*tested*	*tested*	*tested*	*tested*	*tested*
$P = f(\sigma)$ (stress dependence)	*tested*	*tested*	*tested*	*tested*	*tested*
$P = f(\dot{\sigma})$ (stress rate dependence)	*tested*	*tested*	*tested*	*tested*	*tested*
$P = f(t)$ (creep)	-	-	-	-	-
$P = f(T,\dot{\sigma},\sigma)$ (combination)	*tested*	*tested*	*tested*	*tested*	*tested*
$P = f(T,\dot{\sigma},\sigma,t)$ (creep combination)	-	-	-	-	-
Fiber Degradation	*tested*	*tested*	*tested*	*tested*	*tested*
Fabrication-Induced Stresses	*tested*	*tested*	*tested*	*tested*	*tested*
Ply Orientations (d)					
Arbitrary	*tested*	*tested*	*tested*	*tested*	*tested*

(a) Tested 1 buckling mode

(b) Tested 4 vibration modes

(c) Constitutive models: Notation
P: Material Properties
T: Temperature
σ: Stress
$\dot{\sigma}$: Stress rate
t: Time

(d) Tested 3 ply orientations:
Unsymmetric: (0/+45/90)
Symmetric: $(0/45)_s$
Blanced: $(0/90)_s$

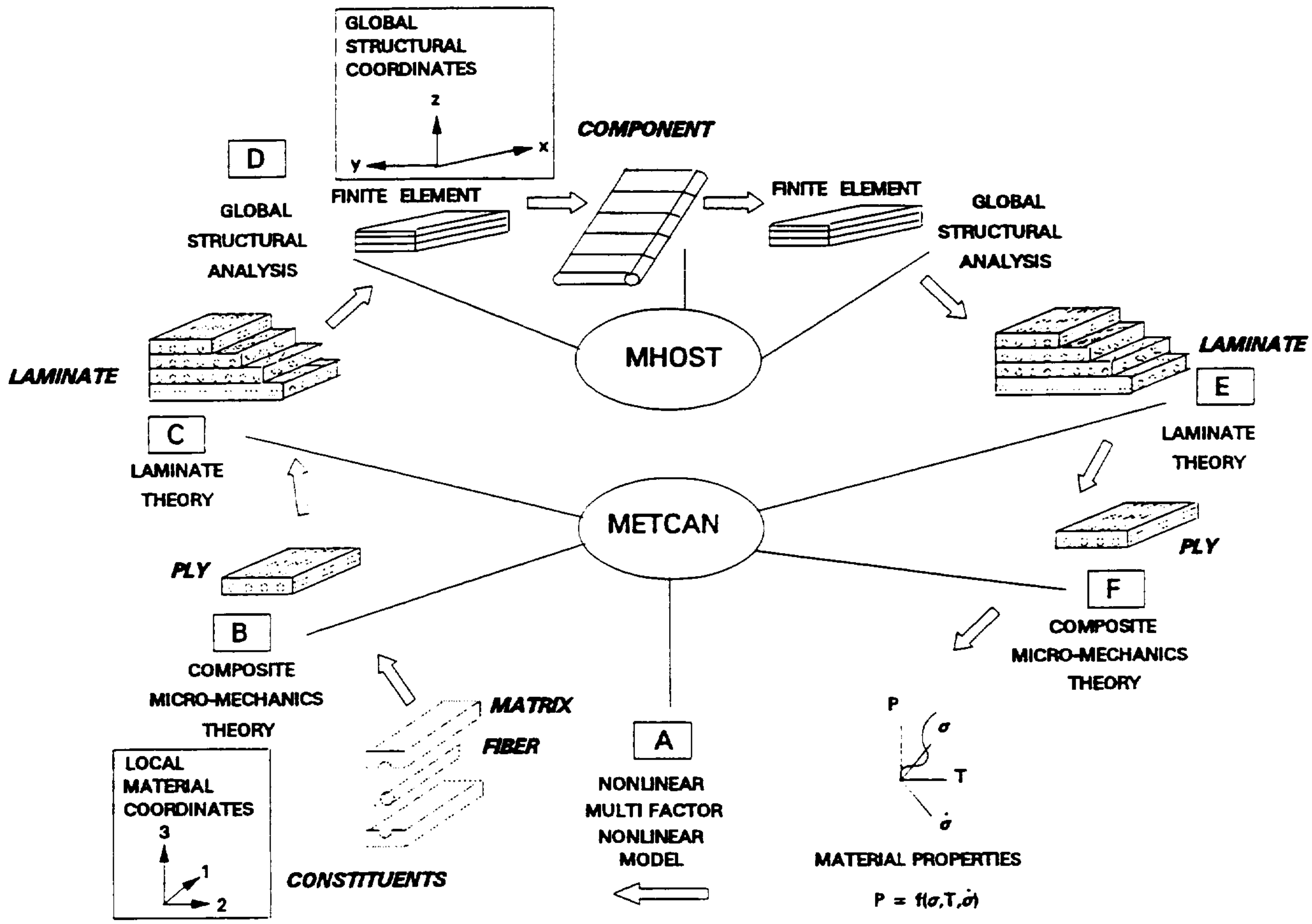


Figure 1 - HITCAN: An Integrated Approach for High Temperature Composite Structural Analysis

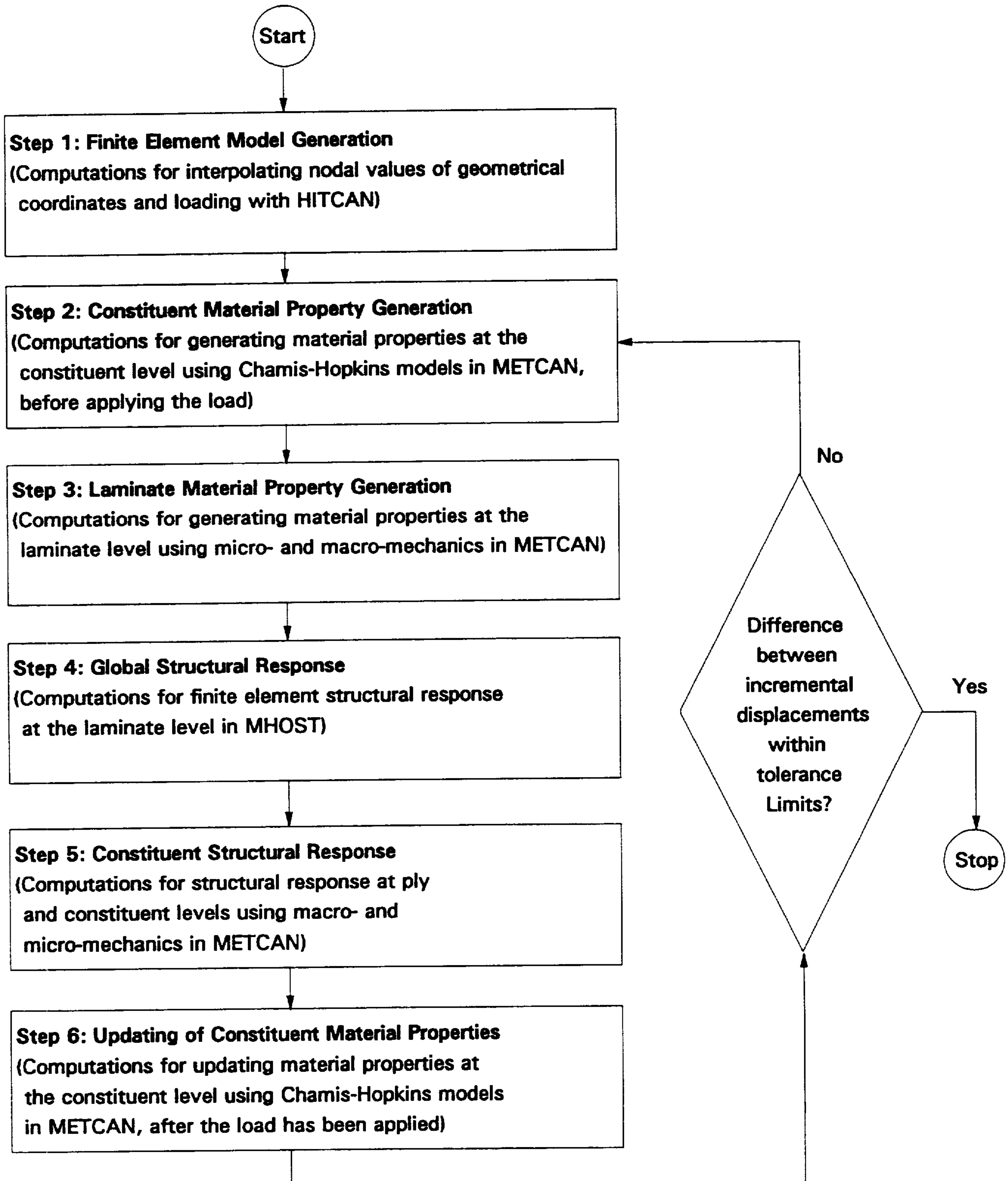


Figure 3 - Flow Chart for HITCAN Computational Procedure

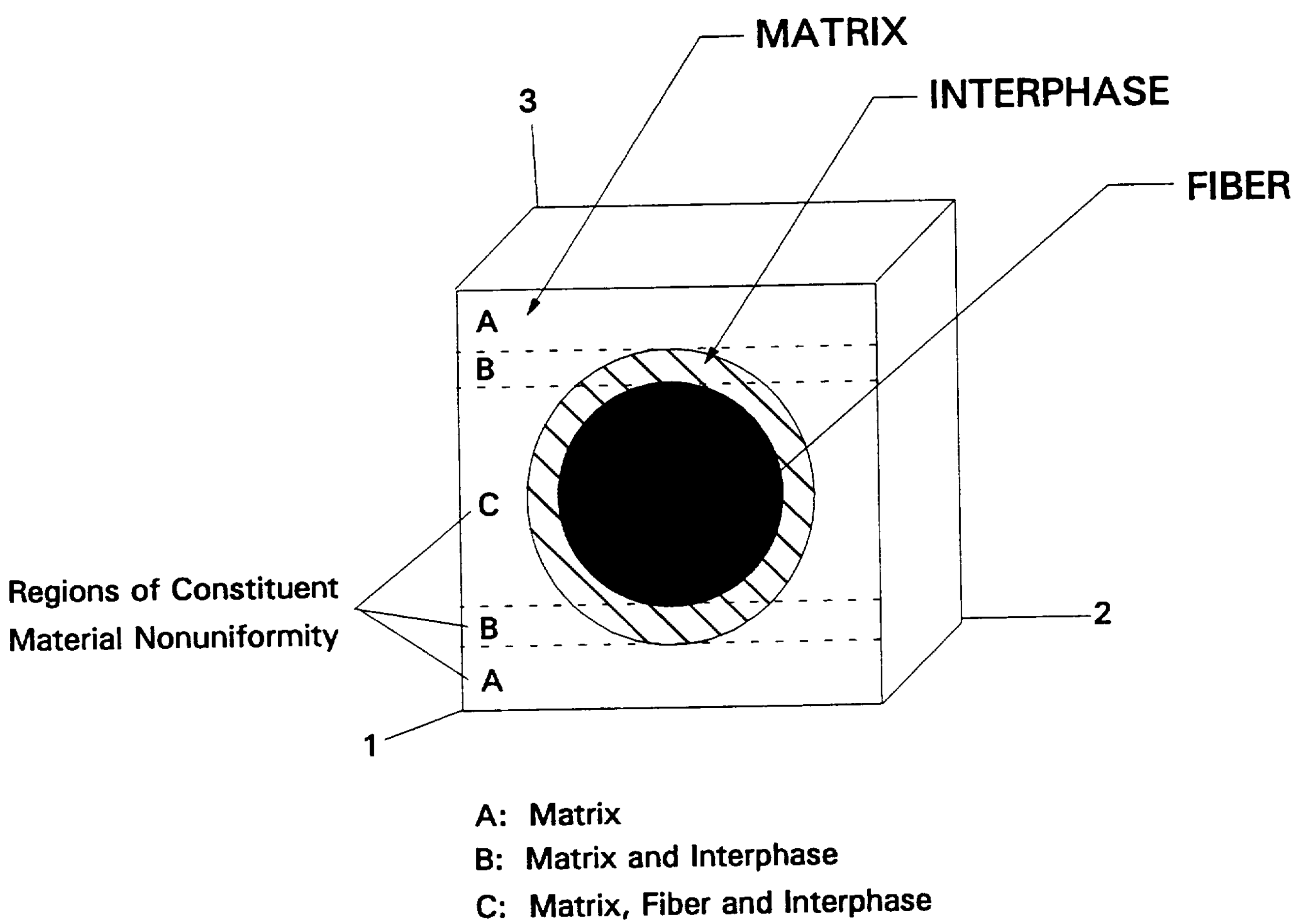


Figure 2 - Schematics for Regions of Constituent Material Nonuniformity

CHAPTER 2

BRIEF DESCRIPTION OF HITCAN

HITCAN presents a synergistic combination of NASA-developed codes: COBSTRAN (Ref. 4), METCAN (Ref. 5), and MHOST (Ref. 6). COBSTRAN provided the finite element mesh generation capability which was enhanced to include new features such as modeling of curved surfaces. METCAN serves 3 important functions: (1) it computes material properties at ply and laminate levels from the user-input properties of composites at the constituent (fiber, matrix, and interphase) level using a nonlinear multi-factor interaction model; (2) it computes stress response at the ply and constituent levels from the MHOST-calculated stress response at the laminate level; (3) it updates the material properties at all levels of the composite structure based on user-selected input/output parameters such as time, temperature loading, and output stresses at each step of the loading increment. MHOST is used to perform the finite element analysis at laminate level.

Figure 1 summarizes the integrated METCAN/MHOST approach. The different regions of constituent materials are shown in Figure 2. The flow chart for the computational procedure used in HITCAN is depicted in Figure 3.

HITCAN can be executed with the minimum information for the characterization of arbitrarily oriented, multilayered composites. The user needs to input the material properties at the most basic level of the composite i.e., the constituents. The code does the rest. To make it even more friendly to use, HITCAN includes a material property database for typical aerospace fiber and matrix materials. The user needs to specify only a code name of the material (rather than having to input all the properties) in the HITCAN input. HITCAN automatically searches, selects, and updates the appropriate properties from its database. The database includes graphite, boron, silicon carbide, and tungsten fibers, and aluminum, titanium, copper, magnesium, and beryllium matrix materials.

HITCAN is continually enhanced as more research bears fruit. It has, however, already been developed and tested for many features qualifying it as a useful design tool for a variety of structures for which HITCAN has been/is being demonstrated.

HITCAN is modular, open-ended, and user-friendly. It includes special features such as fiber degradation effect and fabrication-induced stresses. Because of the multi-level analysis approach, HITCAN offers the utility for studying the influence of individual constituent in-situ behavior of global structural response. These features make HITCAN a powerful, cost-effective tool for analyzing/designing metal matrix composite structures and components.

CHAPTER 3

LIST OF DEMONSTRATION PROBLEMS

A list of features demonstrated in all 13 sample problems included in the present version of the manual, is provided below.

Problem #	Type of Analysis	Type of Structure	Loading		Boundary Conditions	Additional Features	Page #
			Thermal	Mechanical			
1	Static	Beam	Uniform Heating	Concentrated Load	Cantilever	----	DEMO11
2	Static	Plate	Uniform Heating	Concentrated Load	Simply Supported	----	DEMO21
3	Static	Ring	Uniform Heating	Concentrated Load	Cantilever	----	DEMO31
4	Static	Curved Panel	Uniform Heating	External Pressure	Fixed-Free	----	DEMO41
5	Static	Built-up Structure	Uniform Heating	Internal Pressure	Bottom Supported	----	DEMO51
6	Buckling	Curved Panel	----	External Pressure	Fixed-Free	----	DEMO61
7	Buckling	Built-up Structure	----	Distributed Load	Simply Supported-Free	----	DEMO71
8	Buckling	Curved Panel	----	External Pressure	Fixed-Free	Fiber Degradation	DEMO81
9	Buckling	Built-up Structure	----	Distributed Load	Simply Supported-Free	Fiber Degradation	DEMO91
10	Load Stepping & Modal	Curved Panel	Uniform Heating	External Pressure	Fixed-Free	----	DEMO101
11	Load Stepping & Modal	Built-up Structure	Uniform Heating	Internal Pressure	Bottom Supported	----	DEMO111
12	Load Stepping	Curved Panel	Uniform Heating	External Pressure	Fixed-Free	Fabrication-Induced Stresses	DEMO121
13	Load Stepping	Built-up Structure	Uniform Heating	Internal Pressure	Bottom Supported	Fabrication-Induced Stresses	DEMO131

Table II. - Constituent Material Properties At Unstressed Reference Temperature (70 °F) State

SiC Fiber		Ti-15-3-3-3 Matrix	
P_f	0.11 lb/in^3	P_m	0.172 lb/in^3
E_f	62 Mpsi	E_m	12.3 Mpsi
μ_f	0.3 in/in	μ_m	0.32 in/in
G_f	23.8 Mpsi	G_m	4.7 Mpsi
α_f	1.8 ppm	α_m	4.5 ppm
T_{Mf}	4870 °F	T_{Mm}	1800 °F
S_{f11T}	500 ksi	S_{mT}	130 ksi
S_{f11C}	650 ksi	S_{mC}	130 ksi
S_{f22T}	500 ksi	S_{mS}	91 ksi
S_{f22C}	650 ksi		
S_{f12S}	300 ksi		
D_f	5.6 mils		

Notation:

D:	Fiber Diameter
E:	Elastic Modulus
G:	Shear Modulus
S:	Strength
T:	Temperature
P:	Density
μ:	Poisson's Ratio
α:	Coefficient of Thermal Expansion

Subscripts:

C:	Compression
f:	Fiber
M:	Melting
m:	Matrix
s:	Shear
T:	Tension
11:	Direction 11
22:	Direction 22
12:	Direction 12

CHAPTER 4

DEMONSTRATION PROBLEM NO. 1

PROBLEM TYPE:

Static analysis of a solid beam type structure using plate element subjected to thermo-mechanical loading.

PROBLEM DESCRIPTION:

A cantilever beam of 2" length and 0.5 x 0.125 " cross-section is subjected to a concentrated load of 100 lb at the center of free end and a uniform temperature increase from 70 to 1000 F. The beam is made of Sic/Ti-15-3-3-3 composite material (Silicon Carbide fiber, Titanium matrix with 15% Vanadium, 3% Aluminum, 3% Chromium, and 3% Tin, and interphase with average properties of fiber and matrix). The composite laminate consists of 4 (0/45/-45/90) plies of equal thickness with 0.4 fiber volume ratio. The ply lay-up is such that the 0 degree ply is at the top and the 90 degree at the bottom of the beam. The material properties at the reference temperature of 70 F are listed in Table II. The geometry, boundary conditions, loading, and ply lay-up are shown in the figure on next page.

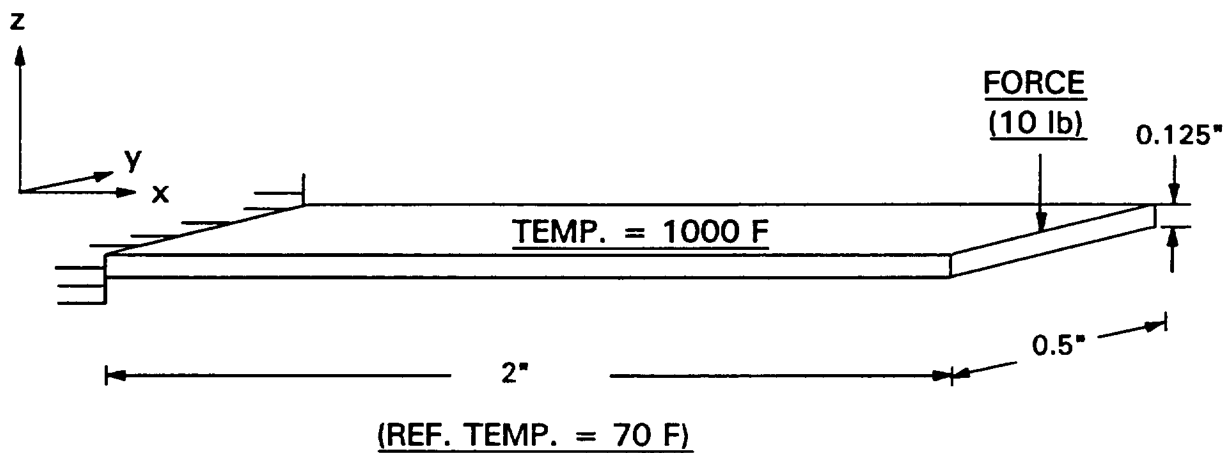
MODELING HINTS:

The finite element mesh consists of 12 elements in x-direction and 4 in y-direction (IU = 13 and JU = 5 on card group # 3). The material property data file, "DATAS BANK" is included in Appendix 1.

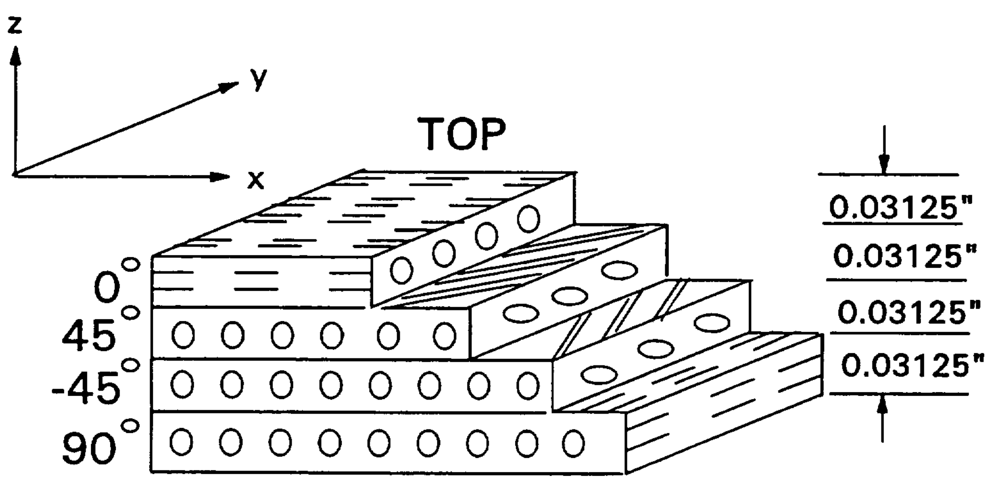
PROBLEM # 1

CANTILEVER BEAM UNDER BENDING & UNIFORM TEMP. LOADINGS FOR (Si C/Ti-15-3-3-3, 0/±45/90); 0.4 FIBER VOLUME RATIO

GEOMETRY, BOUNDARY CONDITIONS, AND LOADING

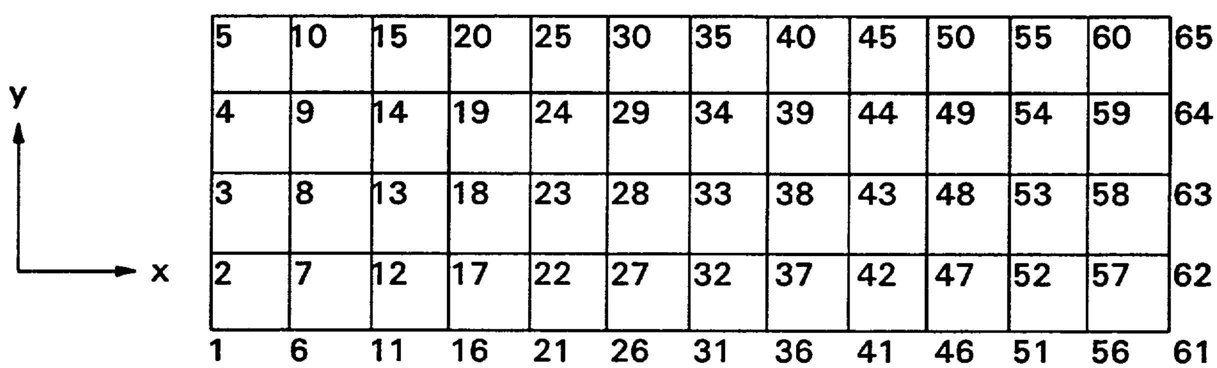


PLY LAY-UP IN Z-DIRECTION

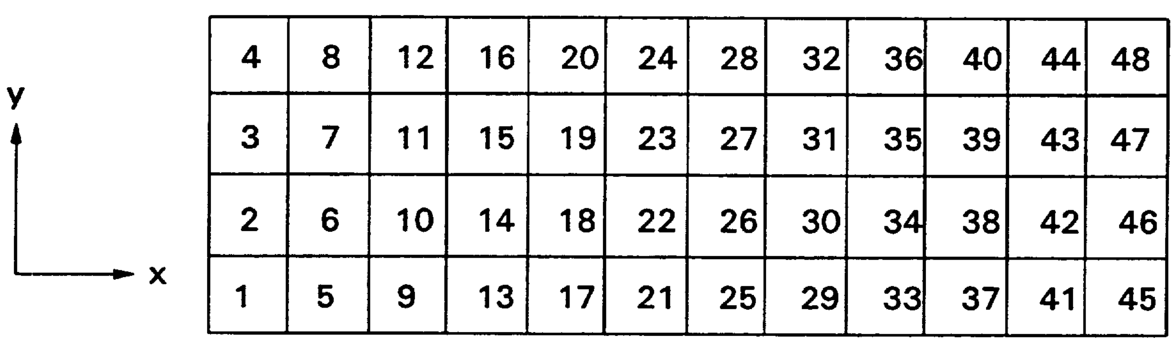


CANTILEVER BEAM UNDER BENDING & UNIFORM TEMP. LOADINGS FOR (Si C/Ti-15-3-3-3, 0/±45/90); 0.4 FIBER VOLUME RATIO

FINITE ELEMENT MESH SHOWING NODE NUMBERS



FINITE ELEMENT MESH SHOWING ELEMENT NUMBERS



INPUT DECK SETUP FOR PROBLEM # 1

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TITLE=L=2", W=0.5", T=0.125", 4(0/45/-45/90)PLIES, FVR=.4,
TITLE=NO FABRICATION EFFECTS, NO FIBER DEGRADATION EFFECTS.
SPLATE
PLATE
FORCE
TEMPERATURE
PLYORDER
UNSYMMETRICAL
ENDOPTIONS
   4
   2
   1  13   5   4
     0.0      2.0
   2
   2
   1   1   1   1   5  10
     1.0
  1
  0
  6
   2   2
  12
     0.0      0.0  0.0625 -0.0625
     0.0      0.5  0.0625 -0.0625
   0
    2.00      0.0  0.0625 -0.0625
    2.00      0.5  0.0625 -0.0625
       0.0      100.0        0.0      100.0        0.0      100.0
SICA TI15  0.03125           0.0       0.40        0.0
       0.0      100.0        0.0      100.0        0.0      100.0
SICA TI15  0.03125           0.0       0.40       45.0
       0.0      100.0        0.0      100.0        0.0      100.0
SICA TI15  0.03125           0.0       0.40      -45.0
       0.0      100.0        0.0      100.0        0.0      100.0
SICA TI15  0.03125           0.0       0.40       90.0
```

INPUT DECK SETUP FOR PROBLEM # 1 (CONTINUED)

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          0.
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      1000.      1000.          0.          0.
      1000.      1000.          0.          0.
      1000.      1000.          0.          0.
  63    3
       -10.
   1    5    1    1
   1    5    1    2
   1    5    1    3
   1    5    1    4
   1    5    1    5
   1    5    1    6
   1   65
   1   65
   3    3   63   63
   1    4
     0.0
```

SAMPLE OUTPUT FOR PROBLEM # 1

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 0 DEG. AT TOP)

FILE: BNNUSCF OUT A1 VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
63	0.617E-02	-0.291E-04	-0.628E-02	0.242E-02	0.332E-02	-0.556E-05

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 3

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.973E+05	-0.103E+05	0.000E+00	-0.230E+03	0.789E+02	0.421E+03
2	-0.438E+05	-0.361E+05	0.000E+00	0.295E+05	-0.757E+03	-0.518E+03
3	-0.415E+05	-0.342E+05	0.000E+00	-0.304E+05	-0.518E+03	0.757E+03
4	0.174E+05	-0.630E+05	0.000E+00	-0.365E+03	-0.421E+03	0.789E+02

NODE # 3
MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 0.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	0.7530E+05	SIGM11A	-0.2125E+05	SIGD11B	0.2291E+05	SIGL11	0.1737E+05
3	SIGF22	-0.6195E+05	SIGM22A	-0.6465E+05	SIGD22B	-0.9125E+05	SIGL22	-0.6297E+05
4	SIGF12	-0.2291E+04	SIGM22B	-0.9125E+05	SIGD22C	-0.6195E+05	SIGL33	0.0000E+00
5	SIGF23	0.5011E+03	SIGM22C	-0.6195E+05	SIGD12B	-0.1171E+04	SIGL12	-0.3647E+03
6	SIGF13	-0.2643E+04	SIGM12A	-0.2204E+03	SIGD12C	-0.1370E+04	SIGL23	-0.4207E+03
7	SIGF33	0.1357E+05	SIGM12B	-0.3835E+03	SIGD23B	0.2562E+03	SIGL13	0.7888E+02
8			SIGM12C	-0.4485E+03	SIGD23C	0.2996E+03		
9			SIGM23A	0.4820E+02	SIGD13B	-0.1351E+04		
10			SIGM23B	0.8387E+02	SIGD13C	-0.1580E+04		
11			SIGM23C	0.9809E+02	SIGD33B	-0.2630E+05		
12			SIGM13A	-0.2542E+03	SIGD33C	0.1357E+05		
13			SIGM13B	-0.4424E+03	SIGD11C	0.2291E+05		
14			SIGM13C	-0.5174E+03				
15			SIGM33A	-0.2531E+05				
16			SIGM33B	-0.2630E+05				
17			SIGM33C	0.1357E+05				
18			SIGM11B	-0.2125E+05				
19			SIGM11C	-0.2125E+05				

TIME REQUIRED TO CARRY OUT THE ANALYSIS 0.079 SEC.
TIME REQUIRED TO : READ IN DATA 0.013 SEC.
DO PREPROCESSING 0.073 SEC.

DEMONSTRATION PROBLEM NO. 2

PROBLEM TYPE:

Static analysis of a solid plate type structure using plate element subjected to thermo-mechanical loading.

PROBLEM DESCRIPTION:

A 6" long, 4" wide, and 0.125" thick plate with all 4 edges simply supported is subjected to a concentrated load of 200 lb at the top center and a uniform temperature increase from 70 to 1000 F. The plate is made of Sic/Ti-15-3-3-3 composite material (Silicon Carbide fiber, Titanium matrix with 15% Vanadium, 3% Aluminum, 3% Chromium, and 3% Tin, and interphase with average properties of fiber and matrix). The composite laminate consists of 4 (0/45/-45/90) plies of equal thickness with 0.4 fiber volume ratio. The ply lay-up is such that the 0 degree ply is at the top and the 90 degree at the bottom of the plate. The material properties at the reference temperature of 70 F are listed in Table II. The geometry, boundary conditions, loading, and ply lay-up are shown in the figure on next page.

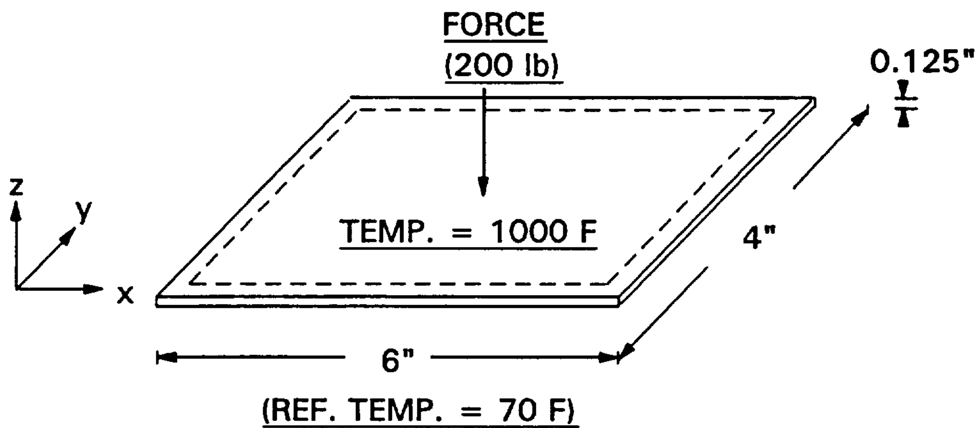
MODELING HINTS:

The finite element mesh consists of 6 elements in x-direction and 4 in y-direction (IU = 7 and JU = 5 on card group # 3). The material property data file, "DATAS BANK" is included in Appendix 1.

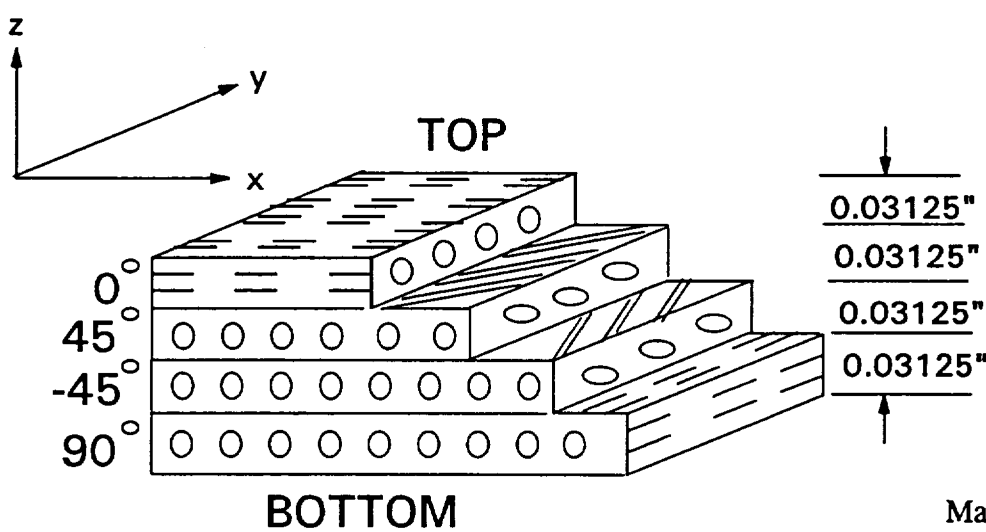
PROBLEM # 2

SIMPLY SUPPORTED PLATE UNDER BENDING & UNIFORM TEMP. LOADINGS FOR (Si C/Ti-15-3-3-3, 0/±45/90); 0.4 FIBER VOLUME RATIO

GEOMETRY, BOUNDARY CONDITIONS, AND LOADING



PLY LAY-UP IN Z-DIRECTION



SIMPLY SUPPORTED PLATE UNDER BENDING & UNIFORM TEMP. LOADINGS FOR (Si C/Ti-15-3-3-3, 0/±45/90); 0.4 FIBER VOLUME RATIO

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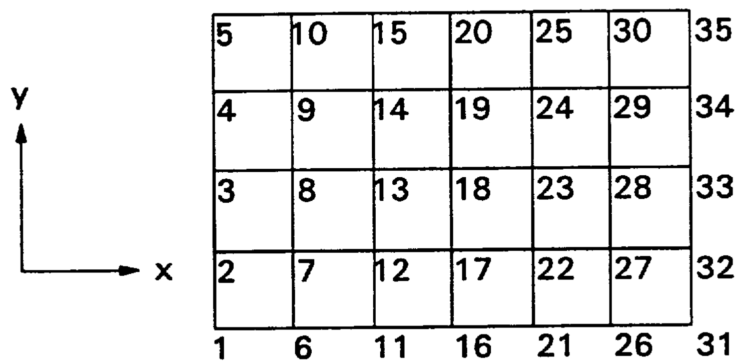
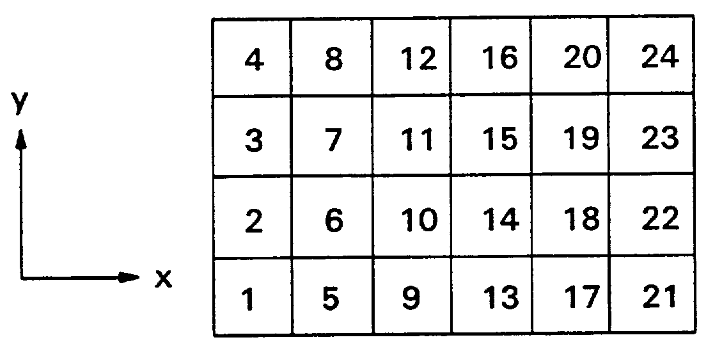


FINITE ELEMENT MESH SHOWING ELEMENT NUMBERS



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TITLE=NO FABRICATION EFFECTS, NO FIBER DEGRADATION EFFECTS.
SPLATE
PLATE
FORCE
TEMPERATURE
PLYORDER
UNSYMMETRICAL
ENDOPTION
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   2
   1   7   5   4
     0.0     6.0
   2
   2
   1   1   1   1   5  10
     1.0
   1
   0
  11
   2   2
   6
     0.0     0.0  0.0625 -0.0625
     0.0     4.0  0.0625 -0.0625
   0
    6.00     0.0  0.0625 -0.0625
    6.00     4.0  0.0625 -0.0625
       0.0     100.0        0.0     100.0        0.0     100.0
SICA TI15  0.03125          0.0       0.40        0.0
       0.0     100.0        0.0     100.0        0.0     100.0
SICA TI15  0.03125          0.0       0.40       45.0
       0.0     100.0        0.0     100.0        0.0     100.0
SICA TI15  0.03125          0.0       0.40      -45.0
       0.0     100.0        0.0     100.0        0.0     100.0
SICA TI15  0.03125          0.0       0.40       90.0
```

INPUT DECK SETUP FOR PROBLEM # 2 (CONTINUED)

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   4    3
   1    2
          0.
      1000.     1000.         0.        0.
      1000.     1000.         0.        0.
      1000.     1000.         0.        0.
      1000.     1000.         0.        0.
  18    3
      -200.
   1    5    1    3
   1    5    1    4
  31   35    1    3
  31   35    1    4
   1   31    5    3
   1   31    5    5
   5   35    5    3
   5   35    5    5
   1   35    1    6
  18   18    0    1
  18   18    0    2
   1   35
   1   35
   7    7   18   18
   1    1    3    3    4    4
     0.0
```

SAMPLE OUTPUT FOR PROBLEM # 2

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 0 DEG. AT TOP)

FILE: PNMUSCF OUT A1 VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
18	-0.725E-38	0.128E-38	-0.978E-02	0.105E-14	-0.499E-14	-0.125E-30

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 18

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	0.142E+05	0.312E+04	0.000E+00	-0.159E+03	-0.452E-10	0.142E-10
2	0.634E+04	-0.112E+04	0.000E+00	0.273E+03	0.470E-10	-0.900E-10
3	0.654E+02	-0.623E+04	0.000E+00	-0.922E+03	-0.900E-10	-0.470E-10
4	-0.435E+04	-0.123E+05	0.000E+00	0.192E+03	-0.142E-10	-0.452E-10

NODE # 7

MICROSTRESSES (in psi. units) IN PLY NO. 1 AT TIME 0.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	0.4841E+05	SIGM11A	-0.8592E+04	SIGD11B	0.5591E+04	SIGL11	0.1421E+05
3	SIGF22	0.1926E+05	SIGM22A	-0.2459E+05	SIGD22B	-0.2184E+05	SIGL22	0.3118E+04
4	SIGF12	-0.9997E+03	SIGM22B	-0.2184E+05	SIGD22C	0.1926E+05	SIGL33	0.0000E+00
5	SIGF23	0.9019E-10	SIGM22C	0.1926E+05	SIGD12B	-0.5111E+03	SIGL12	-0.1591E+03
6	SIGF13	-0.2841E-09	SIGM12A	-0.9616E+02	SIGD12C	-0.5977E+03	SIGL23	-0.4522E-10
7	SIGF33	0.1552E+05	SIGM12B	-0.1673E+03	SIGD23B	0.4611E-10	SIGL13	0.1420E-10
8			SIGM12C	-0.1957E+03	SIGD23C	0.5392E-10		
9			SIGM23A	0.8675E-11	SIGD13B	-0.1453E-09		
10			SIGM23B	0.1510E-10	SIGD13C	-0.1699E-09		
11			SIGM23C	0.1766E-10	SIGD33B	-0.2506E+05		
12			SIGM13A	-0.2733E-10	SIGD33C	0.1552E+05		
13			SIGM13B	-0.4756E-10	SIGD11C	0.5591E+04		
14			SIGM13C	-0.5562E-10				
15			SIGM33A	-0.2654E+05				
16			SIGM33B	-0.2506E+05				
17			SIGM33C	0.1552E+05				
18			SIGM11B	-0.8592E+04				
19			SIGM11C	-0.8592E+04				

TIME REQUIRED TO CARRY OUT THE ANALYSIS 0.044 SEC.
TIME REQUIRED TO : READ IN DATA 0.014 SEC.
DO PREPROCESSING 0.041 SEC.

DEMONSTRATION PROBLEM NO. 3

PROBLEM TYPE:

Static analysis of a solid ring type structure using plate element subjected to thermo-mechanical loading.

PROBLEM DESCRIPTION:

A cantilever quarter (90 degree segment) ring of 1" radius and 0.125 x 0.125" cross-section is subjected to a concentrated load of 10 lb at the center of free end and a uniform temperature increase from 70 to 1000 F. The ring is made of Sic/Ti-15-3-3-3 composite material (Silicon Carbide fiber, Titanium matrix with 15% Vanadium, 3% Aluminum, 3% Chromium, and 3% Tin, and interphase with average properties of fiber and matrix). The composite laminate consists of 4 (0/45/-45/90) plies of equal thickness with 0.4 fiber volume ratio. The ply lay-up is such that the 0 degree ply is at the top and the 90 degree at the bottom of the ring. The material properties at the reference temperature of 70 F are listed in Table II. The geometry, boundary conditions, loading, and ply lay-up are shown in the figure on next page.

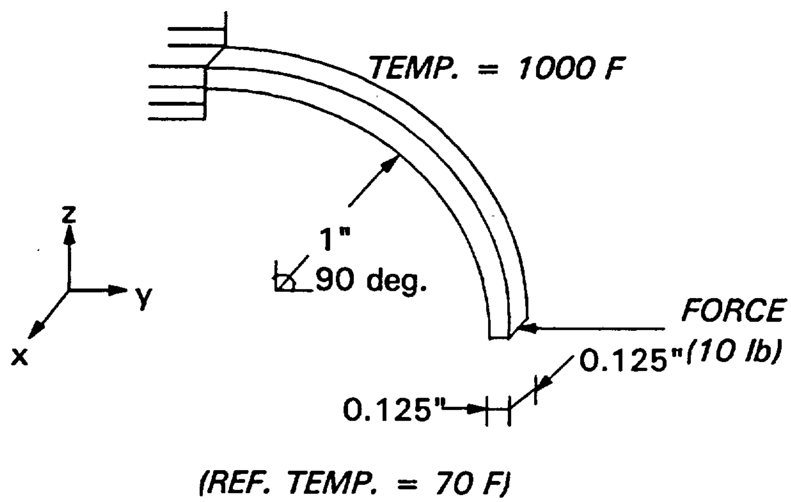
MODELING HINTS:

The finite element mesh consists of 4 elements in the x-direction and 9 along the curved edge (IU = 5 and JU = 10 on card group # 3). The material property data file, "DATAS BANK" is included in Appendix 1.

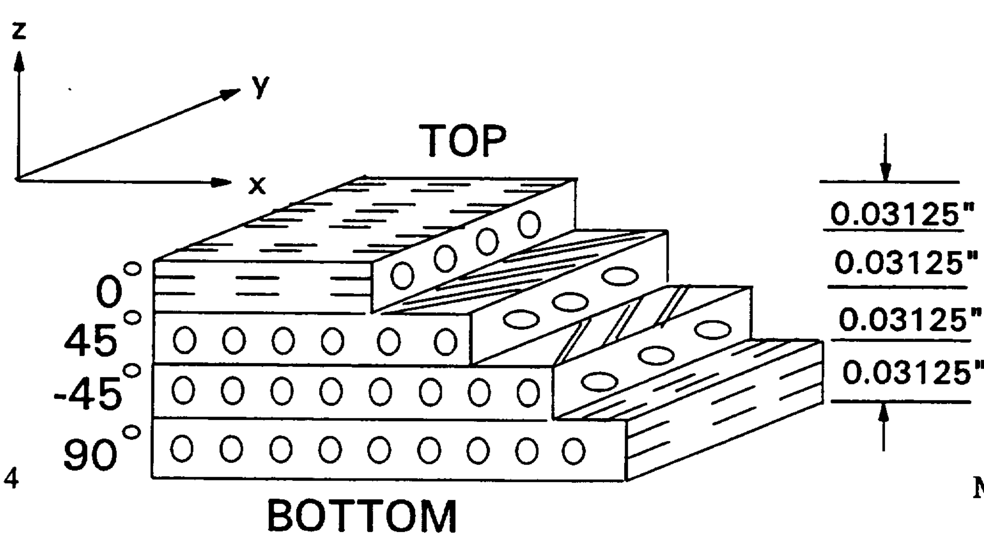
PROBLEM # 3

CANTILEVER RING UNDER BENDING AND UNIFORM TEMPERATURE LOADINGS FOR (Si C/Ti-15-3-3-3, 0/±45/90); 0.4 FIBER VOLUME RATIO

GEOMETRY, BOUNDARY CONDITIONS, AND LOADING

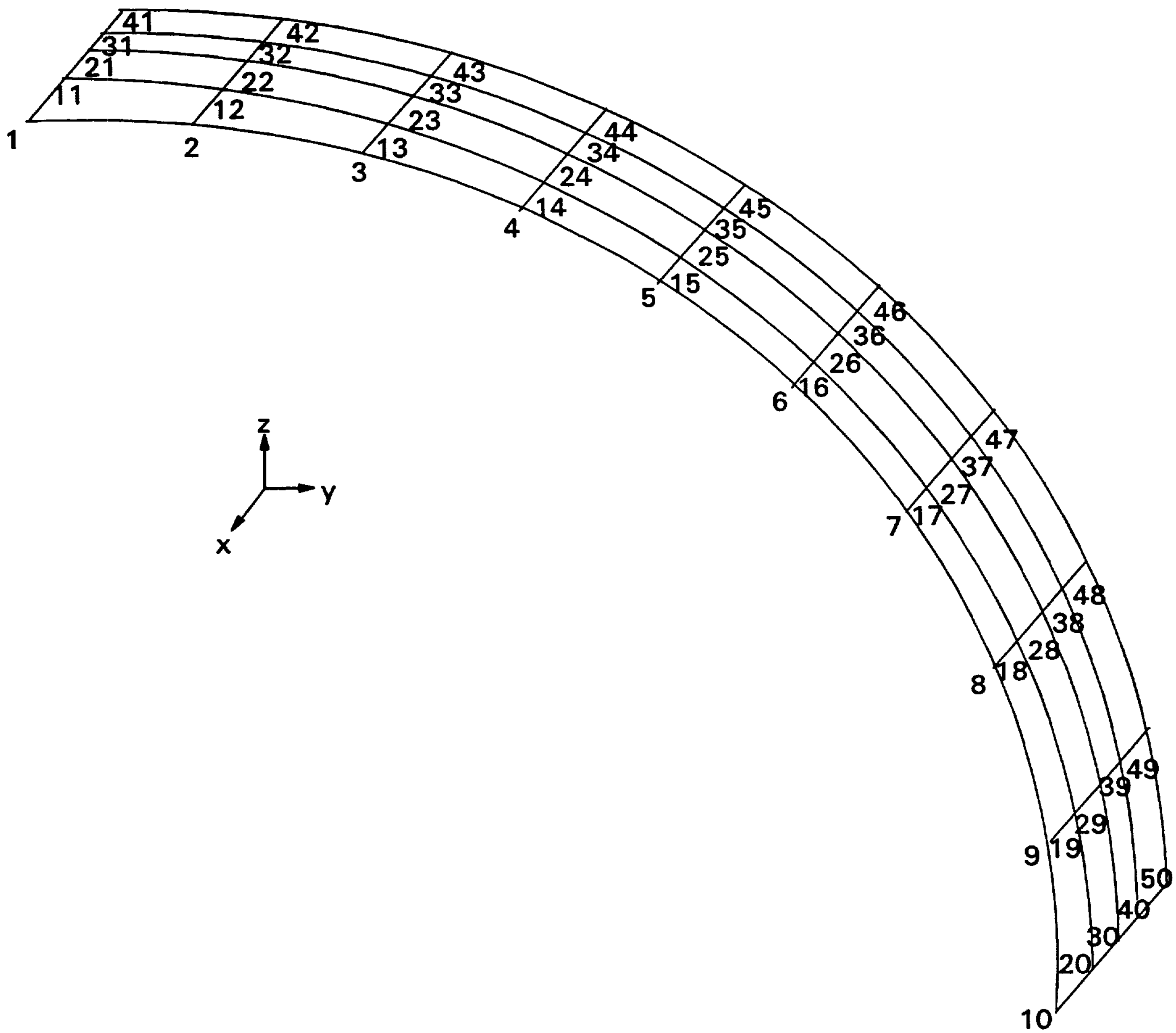


PLY LAY-UP IN Z-DIRECTION



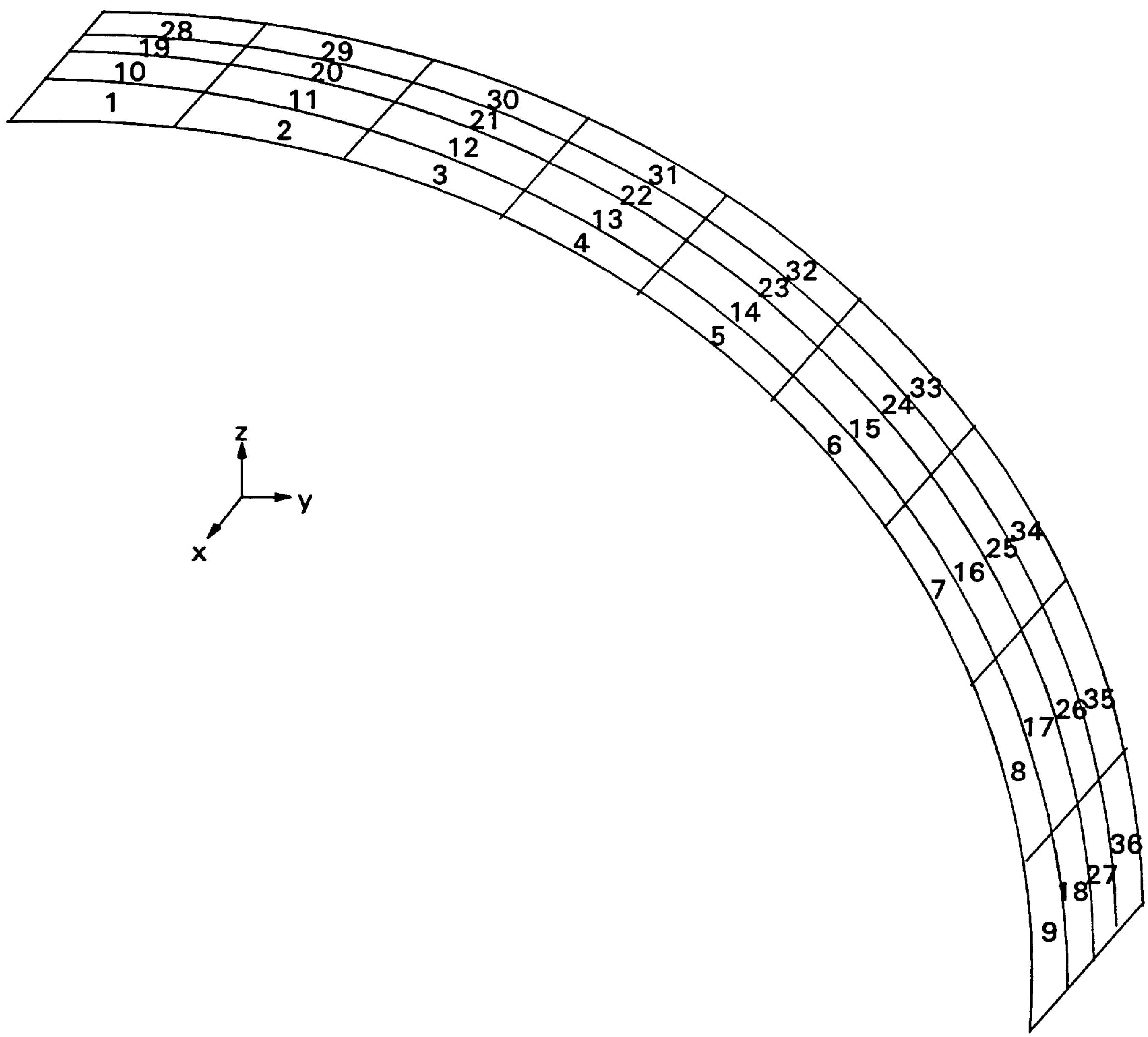
CANTILEVER RING UNDER BENDING & UNIFORM TEMP. LOADINGS FOR (Si C/Ti-15-3-3-3, 0/±45/90); 0.4 FIBER VOLUME RATIO

FINITE ELEMENT MESH SHOWING NODE NUMBERS



CANTILEVER RING UNDER BENDING & UNIFORM TEMP. LOADINGS FOR (Si C/Ti-15-3-3-3, 0/±45/90); 0.4 FIBER VOLUME RATIO

FINITE ELEMENT MESH SHOWING ELEMENT NUMBERS



INPUT DECK SETUP FOR PROBLEM # 3

```
FILE: RNNUSCF   DEMO     A1                VM/SP CONVERSATIONAL MONITO SYSTEM

TITLE=PROBLEM # 3, STATIC ANALYSIS FOR QUARTER RING,
TITLE=FIXED AT ONE END,CONC. LOAD(10 LB) AT CENTER TOP OF OTHER END,
TITLE=UNIFORM TEMP. OF 1000 F (REFERENCE TEMP. = 70 F),
TITLE=R=1", W=0.125", T=0.125", 4(0/45/-45/90)PLIES, FVR=.4, 4X9 MESH
TITLE=NO FABRICATION EFFECTS, NO FIBER DEGRADATION EFFECTS.
SPLATE
PLATE
FORCE
PLYORDER
UNSYMMETRIC
TEMPERATURE
ENDOPTION
   4
   5
   3   5  10   4
   2
   2
   1   1   1   1   5  10
     1.0
   1
   0
   6
  10  10  10  10  10
   1
  0.0000  0.0000  1.0000  0.1250
  0.0000  0.1737  0.9848  0.1250
  0.0000  0.3420  0.9397  0.1250
  0.0000  0.5000  0.8660  0.1250
  0.0000  0.6428  0.7661  0.1250
  0.0000  0.7661  0.6428  0.1250
  0.0000  0.8660  0.5000  0.1250
  0.0000  0.9397  0.3420  0.1250
  0.0000  0.9848  0.1737  0.1250
  0.0000  1.0000  0.0000  0.1250
   1
  .03125  0.0000  1.0000  0.1250
  .03125  0.1737  0.9848  0.1250
  .03125  0.3420  0.9397  0.1250
  .03125  0.5000  0.8660  0.1250
  .03125  0.6428  0.7661  0.1250
  .03125  0.7661  0.6428  0.1250
  .03125  0.8660  0.5000  0.1250
  .03125  0.9397  0.3420  0.1250
  .03125  0.9848  0.1737  0.1250
  .03125  1.0000  0.0000  0.1250
   1
```

INPUT DECK SETUP FOR PROBLEM # 3 (CONTINUED)

```
FILE: RNNUSCF    DEMO      A1                    VM/SP CONVERSATIONAL MONITO SYSTEM
  0.0625  0.0000  1.0000  0.1250
  0.0625  0.1737  0.9848  0.1250
  0.0625  0.3420  0.9397  0.1250
  0.0625  0.5000  0.8660  0.1250
  0.0625  0.6428  0.7661  0.1250
  0.0625  0.7661  0.6428  0.1250
  0.0625  0.8660  0.5000  0.1250
  0.0625  0.9397  0.3420  0.1250
  0.0625  0.9848  0.1737  0.1250
  0.0625  1.0000  0.0000  0.1250
   1
  .09375  0.0000  1.0000  0.1250
  .09375  0.1737  0.9848  0.1250
  .09375  0.3420  0.9397  0.1250
  .09375  0.5000  0.8660  0.1250
  .09375  0.6428  0.7661  0.1250
  .09375  0.7661  0.6428  0.1250
  .09375  0.8660  0.5000  0.1250
  .09375  0.9397  0.3420  0.1250
  .09375  0.9848  0.1737  0.1250
  .09375  1.0000  0.0000  0.1250
   0
  0.1250  0.0000  1.0000  0.1250
  0.1250  0.1737  0.9848  0.1250
  0.1250  0.3420  0.9397  0.1250
  0.1250  0.5000  0.8660  0.1250
  0.1250  0.6428  0.7661  0.1250
  0.1250  0.7661  0.6428  0.1250
  0.1250  0.8660  0.5000  0.1250
  0.1250  0.9397  0.3420  0.1250
  0.1250  0.9848  0.1737  0.1250
  0.1250  1.0000  0.0000  0.1250
      0.0      100.0      0.0     100.0      0.0     100.0
SICA TI15    0.03125      0.0      0.40      0.0
      0.0      100.0      0.0     100.0      0.0     100.0
SICA TI15    0.03125      0.0      0.40     45.0
      0.0      100.0      0.0     100.0      0.0     100.0
SICA TI15    0.03125      0.0      0.40    -45.0
      0.0      100.0      0.0     100.0      0.0     100.0
SICA TI15    0.03125      0.0      0.40     90.0
   4   3
   1   2
      0.
     1000.     1000.      0.       0.
     1000.     1000.      0.       0.
     1000.     1000.      0.       0.
```

INPUT DECK SETUP FOR PROBLEM # 3 (CONTINUED)

```
FILE: RNNUSCF   DEMO     A1                    VM/SP CONVERSATIONAL MONITO SYSTEM
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
    1000.      1000.      0.       0.
 30    2
    -10.0
```

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 0 DEG. AT TOP)

FILE: RNMUSCF OUT A1 VM/SP CONVERSATIONAL MONITOR PAGE 00001

```
 1  41  10  1
 1  41  10  2
 1  41  10  3
 1  41  10  4
 1  41  10  5
 1  41  10  6
 1  50
 1  50
10  10   2  2
 1   1
  0.0
```

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
30	0.633E-03	-0.153E-01	-0.148E-01	-0.245E-01	-0.127E-02	0.137E-02

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 2

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.150E+05	0.164E+05	0.000E+00	0.348E+03	0.736E+02	-0.205E+03
2	0.213E+05	0.732E+04	0.000E+00	0.710E+04	0.199E+03	0.422E+03
3	0.267E+05	0.149E+05	0.000E+00	0.666E+03	0.422E+03	-0.199E+03
4	0.221E+05	0.279E+05	0.000E+00	-0.141E+04	0.205E+03	0.736E+02

NODE # 2

MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 0.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	0.5580E+05	SIGM11A	-0.3652E+03	SIGD11B	0.9564E+04	SIGL11	0.2210E+05
3	SIGF22	0.4980E+05	SIGM22A	-0.9568E+04	SIGD22B	0.4224E+04	SIGL22	0.2795E+05
4	SIGF12	-0.8839E+04	SIGM22B	0.4224E+04	SIGD22C	0.4980E+05	SIGL33	0.0000E+00
5	SIGF23	0.4677E+03	SIGM22C	0.4980E+05	SIGD12B	-0.4519E+04	SIGL12	-0.1407E+04
6	SIGF13	0.1288E+04	SIGM12A	-0.8502E+03	SIGD12C	-0.5285E+04	SIGL23	0.2051E+03
7	SIGF33	0.1628E+05	SIGM12B	-0.1480E+04	SIGD23B	0.2391E+03	SIGL13	0.7362E+02
8			SIGM12C	-0.1730E+04	SIGD23C	0.2796E+03		
9			SIGM23A	0.4498E+02	SIGD13B	0.6587E+03		
10			SIGM23B	0.7828E+02	SIGD13C	0.7704E+03		
11			SIGM23C	0.9155E+02	SIGD33B	-0.2461E+05		
12			SIGM13A	0.1239E+03	SIGD33C	0.1628E+05		
13			SIGM13B	0.2157E+03	SIGD11C	0.9564E+04		
14			SIGM13C	0.2522E+03				
15			SIGM33A	-0.2703E+05				
16			SIGM33B	-0.2461E+05				
17			SIGM33C	0.1628E+05				
18			SIGM11B	-0.3652E+03				
19			SIGM11C	-0.3652E+03				

TIME REQUIRED TO CARRY OUT THE ANALYSIS	0.061 SEC.
TIME REQUIRED TO : READ	0.028 SEC.
DO PREPROCESSING	0.055 SEC.

DEMONSTRATION PROBLEM NO. 4

PROBLEM TYPE:

Static analysis of a solid curved panel type structure using plate element subjected to thermo-mechanical loading.

PROBLEM DESCRIPTION:

A curved panel (20 degree segment) of 6" radius, 2" width, and 0.125" thickness with both straight edges clamped and both curved edges free, is subjected to an external pressure load of 2000 psi at the top surface and a uniform temperature increase from 70 to 1000 F. The curved panel is made of Sic/Ti-15-3-3-3 composite material (Silicon Carbide fiber, Titanium matrix with 15% Vanadium, 3% Aluminum, 3% Chromium, and 3% Tin, and interphase with average properties of fiber and matrix). The composite laminate consists of 4 (0/45/-45/90) plies of equal thickness with 0.4 fiber volume ratio. The ply lay-up is such that the 0 degree ply is at the top and the 90 degree at the bottom of the curved panel. The material properties at the reference temperature of 70 F are listed in Table II. The geometry, boundary conditions, loading, and ply lay-up are shown in the figure on next page.

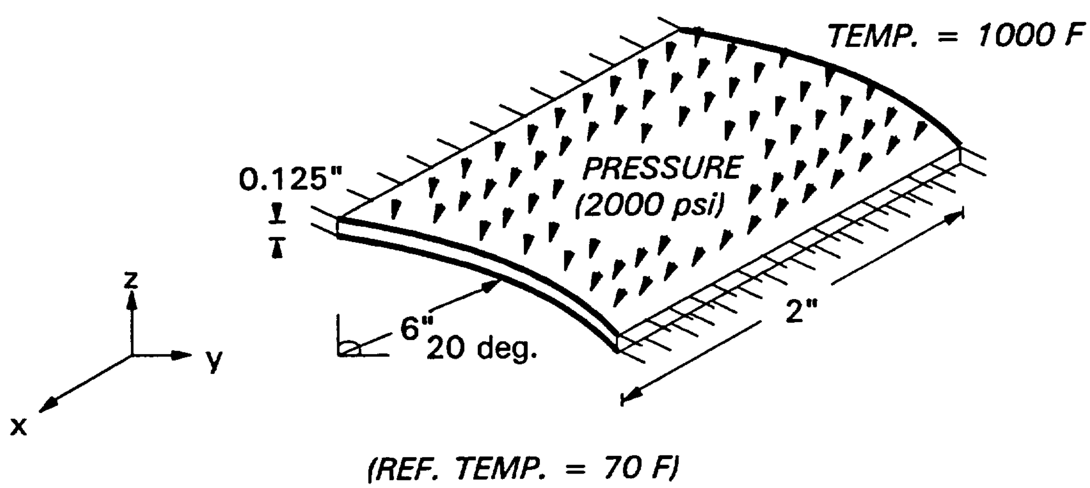
MODELING HINTS:

The finite element mesh consists of 8 elements in the x-direction and 8 along the curved edge (IU = 9 and JU = 9 on card group # 3). The material property data file, "DATAS BANK" is included in Appendix 1.

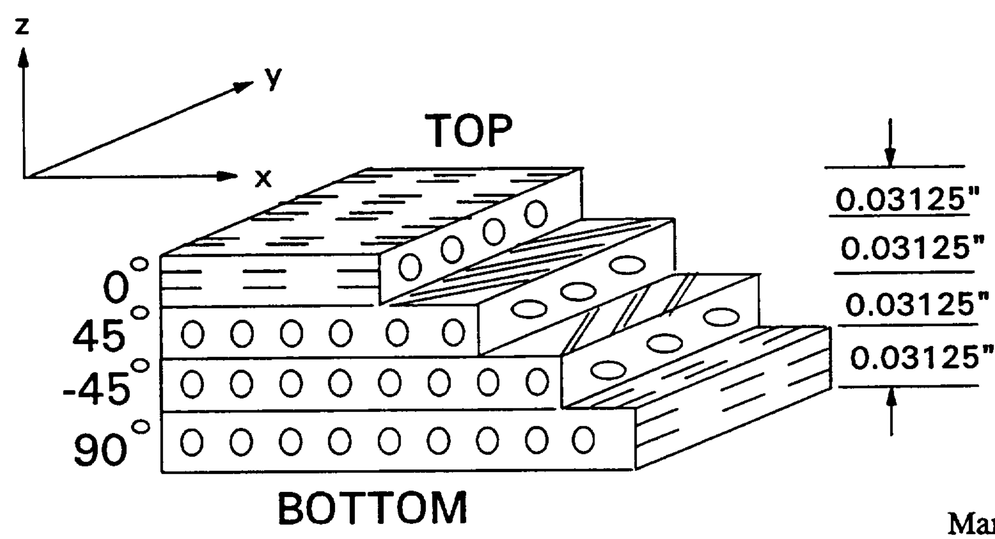
PROBLEM # 4

FIXED-FREE CURVED PANEL UNDER BENDING & UNIFORM TEMP. LOADINGS FOR (Si C/Ti-15-3-3-3, 0/±45/90); 0.4 FIBER VOLUME RATIO

GEOMETRY, BOUNDARY CONDITIONS, AND LOADING

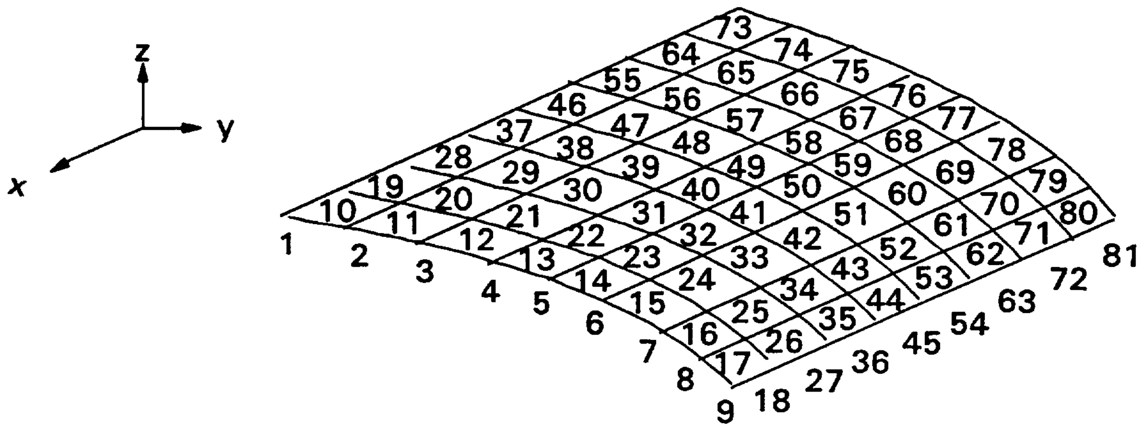


PLY LAY-UP IN Z-DIRECTION

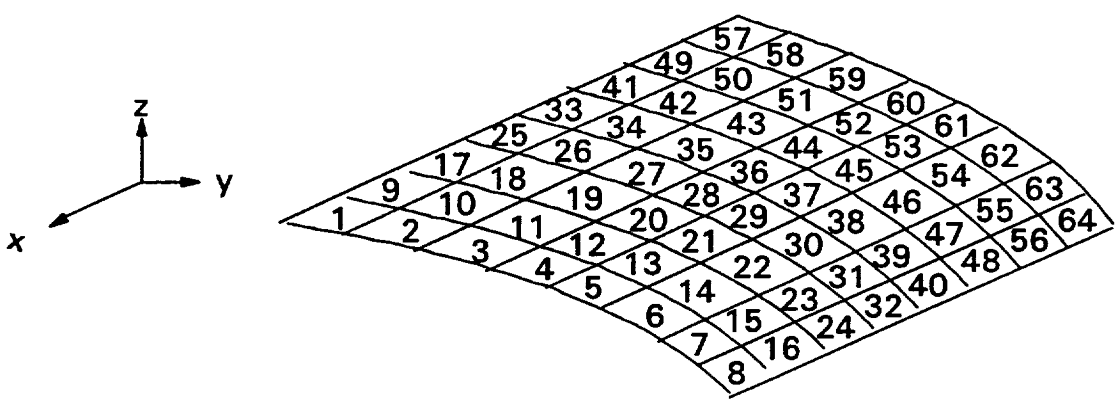


FIXED-FREE CURVED PANEL UNDER BENDING & UNIFORM TEMP. LOADINGS FOR (Si C/Ti-15-3-3-3, 0/±45/90); 0.4 FIBER VOLUME RATIO

FINITE ELEMENT MESH SHOWING NODE NUMBERS



FINITE ELEMENT MESH SHOWING ELEMENT NUMBERS



INPUT DECK SETUP FOR PROBLEM # 4

```
FILE: SNNUSCF   DEMO    A1                VM/SP CONVERSATIONAL MONITOR SYSTEM

TITLE=PROBLEM # 4, STATIC ANALYSIS FOR CURVED PANEL (20 deg. SHELL ROOF),
TITLE=FIXED STRAIGHT EDGES, FREE CURVED EDGES, EXTERNAL PRESSURE (2000
TITLE=PSI), UNIFORM TEMP. OF 1000 F (REFERENCE TEMP. = 70 F),
TITLE=R=6", W=2", T=0.125", 4(0/45/-45/90)PLIES, FVR=.4, 8X8 MESH
TITLE=NO FABRICATION EFFECTS, NO FIBER DEGRADATION EFFECTS.
SPLATE
PLATE
PRESSURE
TEMPERATURE
PLYORDER
UNSYMMETRICAL
ENDOPTION
   4
   2
   4    9    9    4
      0.       2.
   2
   2
   1    1    1   50   95   20
     1.0
   0
   0
  11
   5    5
   8
      0.  -1.0420  5.9100  0.1250
      0.  -0.5230  5.9775  0.1250
      0.       0.  6.0000  0.1250
      0.   0.5230  5.9775  0.1250
      0.   1.0420  5.9100  0.1250
   0
      2.  -1.0420  5.9100  0.1250
      2.  -0.5230  5.9775  0.1250
      2.       0.  6.0000  0.1250
      2.   0.5230  5.9775  0.1250
      2.   1.0420  5.9100  0.1250
       0.0      100.0        0.0      100.0        0.0      100.0
SICA TI15    0.03125        0.0       0.40        0.0
       0.0      100.0        0.0      100.0        0.0      100.0
SICA TI15    0.03125        0.0       0.40       45.0
       0.0      100.0        0.0      100.0        0.0      100.0
SICA TI15    0.03125        0.0       0.40      -45.0
       0.0      100.0        0.0      100.0        0.0      100.0
```

INPUT DECK SETUP FOR PROBLEM # 4 (CONTINUED)

```
FILE: SNNUSCF DEMO      A1                 VM/SP CONVERSATIONAL MONITOR SYSTEM

SICA TI15    0.03125       0.0       0.40       90.0
   4   3
   1   2
        0.
     1000.      1000.     000.0     2000.
     1000.      1000.     000.0     2000.
     1000.      1000.     000.0     2000.
     1000.      1000.     000.0     2000.
     1000.      1000.     000.0     2000.
     1000.      1000.     000.0     2000.
     1000.      1000.     000.0     2000.
     1000.      1000.     000.0     2000.
     1000.      1000.     000.0     2000.
     1000.      1000.     000.0     2000.
   1  73    9    2
   1  73    9    3
   1  73    9    4
   1  73    9    5
   1  73    9    6
   9  81    9    2
   9  81    9    3
   9  81    9    4
   9  81    9    5
   9  81    9    6
  37  45    8    1
   1  81
   1  81
   5   5
   1   4
     0.0
```

SAMPLE OUTPUT FOR PROBLEM # 4

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 0 DEG. AT TOP)

FILE: SNNUSCF OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
5	-0.412E-02	-0.424E-05	-0.315E-02	0.118E-03	0.217E-02	-0.429E-04

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 5

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.825E+05	0.407E+04	0.000E+00	-0.111E+03	-0.121E+03	-0.442E+02
2	-0.386E+05	-0.320E+05	0.000E+00	0.327E+05	0.250E+03	-0.116E+03
3	-0.474E+05	-0.396E+05	0.000E+00	-0.350E+05	-0.116E+03	-0.250E+03
4	0.835E+04	-0.820E+05	0.000E+00	0.561E+03	0.442E+02	-0.121E+03

NODE # 5

MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 0.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	0.6395E+05	SIGM11A	-0.2872E+05	SIGD11B	0.1646E+05	SIGL11	0.8352E+04
3	SIGF22	-0.8542E+05	SIGM22A	-0.7617E+05	SIGD22B	-0.1113E+06	SIGL22	-0.8203E+05
4	SIGF12	0.3522E+04	SIGM22B	-0.1113E+06	SIGD22C	-0.8542E+05	SIGL33	0.0000E+00
5	SIGF23	-0.7683E+03	SIGM22C	-0.8542E+05	SIGD12B	0.1801E+04	SIGL12	0.5606E+03
6	SIGF13	0.2775E+03	SIGM12A	0.3388E+03	SIGD12C	0.2106E+04	SIGL23	0.4417E+02
7	SIGF33	0.1286E+05	SIGM12B	0.5896E+03	SIGD23B	-0.3928E+03	SIGL13	-0.1209E+03
8			SIGM12C	0.6895E+03	SIGD23C	-0.4593E+03		
9			SIGM23A	-0.7390E+02	SIGD13B	0.1419E+03		
10			SIGM23B	-0.1286E+03	SIGD13C	0.1659E+03		
11			SIGM23C	-0.1504E+03	SIGD33B	-0.2674E+05		
12			SIGM13A	0.2669E+02	SIGD33C	0.1286E+05		
13			SIGM13B	0.4645E+02	SIGD11C	0.1646E+05		
14			SIGM13C	0.5433E+02				
15			SIGM33A	-0.2498E+05				
16			SIGM33B	-0.2674E+05				
17			SIGM33C	0.1286E+05				
18			SIGM11B	-0.2872E+05				
19			SIGM11C	-0.2872E+05				

TIME REQUIRED TO CARRY OUT THE ANALYSIS 0.098 SEC.

TIME REQUIRED TO : READ IN DATA 0.014 SEC.

DO PREPROCESSING 0.091 SEC.

DEMONSTRATION PROBLEM NO. 5

PROBLEM TYPE:

Static analysis of a hollow sandwich type built-up structure using plate element subjected to thermo-mechanical loading.

PROBLEM DESCRIPTION:

A hollow built-up structure of 0.5" length, 0.2" width, 0.075" total thickness, 0.02" thickness of top plate, 0.01" thickness of bottom plate, and 3 spars in the x-z plane equally spaced in the y-direction with 0.02" thickness the z-direction, with bottom surface fixed in vertical direction, is subjected to an internal pressure load of 2000 psi and a uniform temperature increase from 70 to 1000 F. The built-up structure is made of Sic/Ti-15-3-3-3 composite material (Silicon Carbide fiber, Titanium matrix with 15% Vanadium, 3% Aluminum, 3% Chromium, and 3% Tin, and interphase with average properties of fiber and matrix). The composite laminate consists of 4 (90/0/0/90) plies of equal thickness for the top plate, 2 (90/90) plies of equal thickness for the bottom plate, and 4 (0/0/0/0) plies of equal thickness for the spars, all with 0.4 fiber volume ratio. The ply lay-up is symmetric for all parts of the structure. The material properties at the reference temperature of 70 F are listed in Table II. The geometry, boundary conditions, loading, and ply lay-up are shown in the figure on next page.

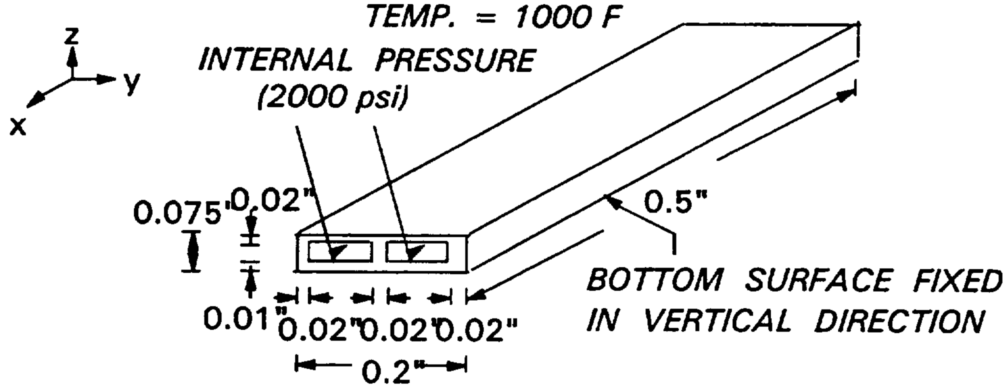
MODELING HINTS:

The finite element mesh consists of 4 elements in the x-direction and 8 in the y-direction for both the top and bottom plates and 4 elements in the x-direction and 1 element in the z-direction for all each of the 3 spars. The material property data file, "DATAS BANK" is included in Appendix 1.

PROBLEM # 5

BOTTOM SUPPORTED BUILT-UP STRUCTURE UNDER BENDING & UNIFORM TEMP. LOADINGS
FOR (Si C/Ti-15-3-3-3, TOP:$[90,0]_s$, BOTTOM:$[90]_s$, SPARS:$4[0]_s$); 0.4 FIBER VOLUME RATIO

GEOMETRY, BOUNDARY CONDITIONS, AND LOADING

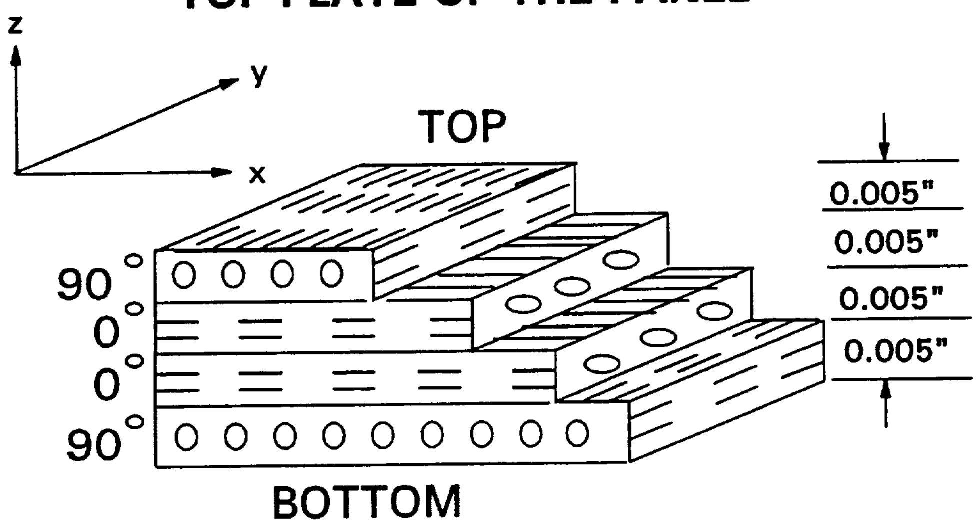


(REF. TEMP. = 70 F)

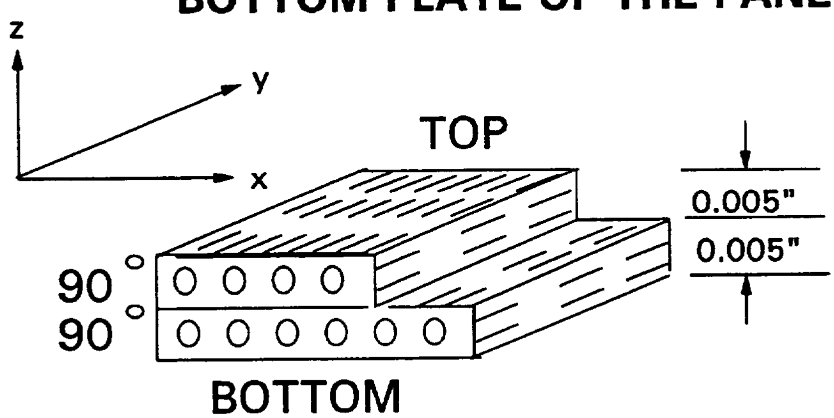
BOTTOM SUPPORTED BUILT-UP STRUCTURE UNDER BENDING & UNIFORM TEMP. LOADINGS FOR (Si C/Ti-15-3-3-3, 0/±45/90); 0.4 FIBER VOLUME RATIO

PLY LAY-UP IN Z-DIRECTION

TOP PLATE OF THE PANEL



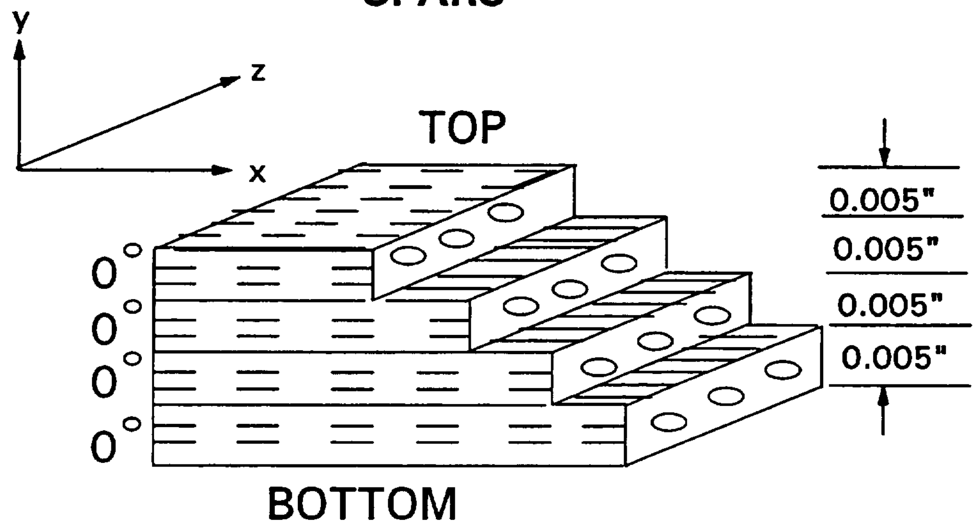
BOTTOM PLATE OF THE PANEL



BOTTOM SUPPORTED BUILT-UP STRUCTURE UNDER BENDING & UNIFORM TEMP. LOADINGS FOR (Si C/Ti-15-3-3-3, 0/±45/90); 0.4 FIBER VOLUME RATIO

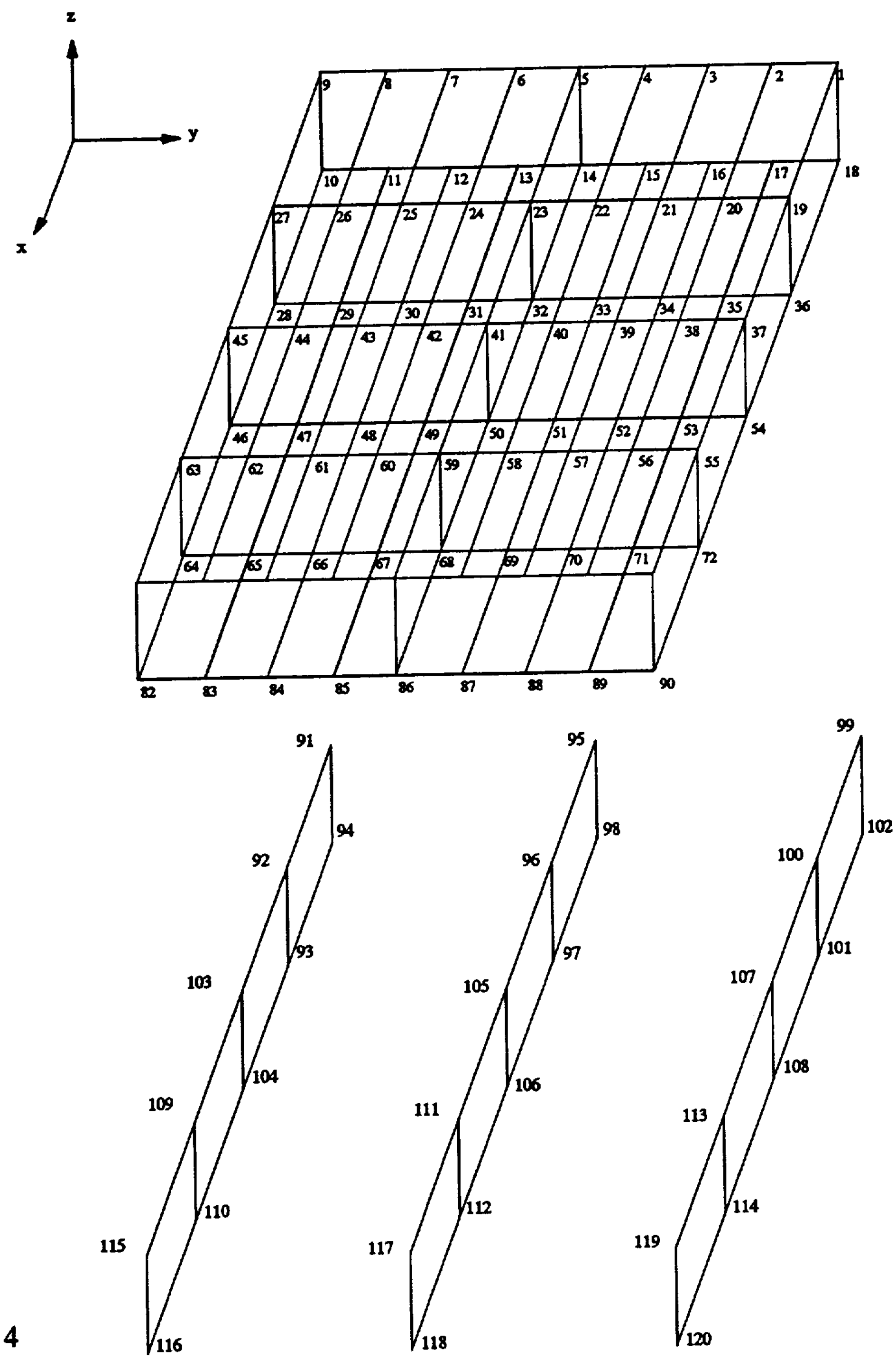
PLY LAY-UP IN Y-DIRECTION

SPARS



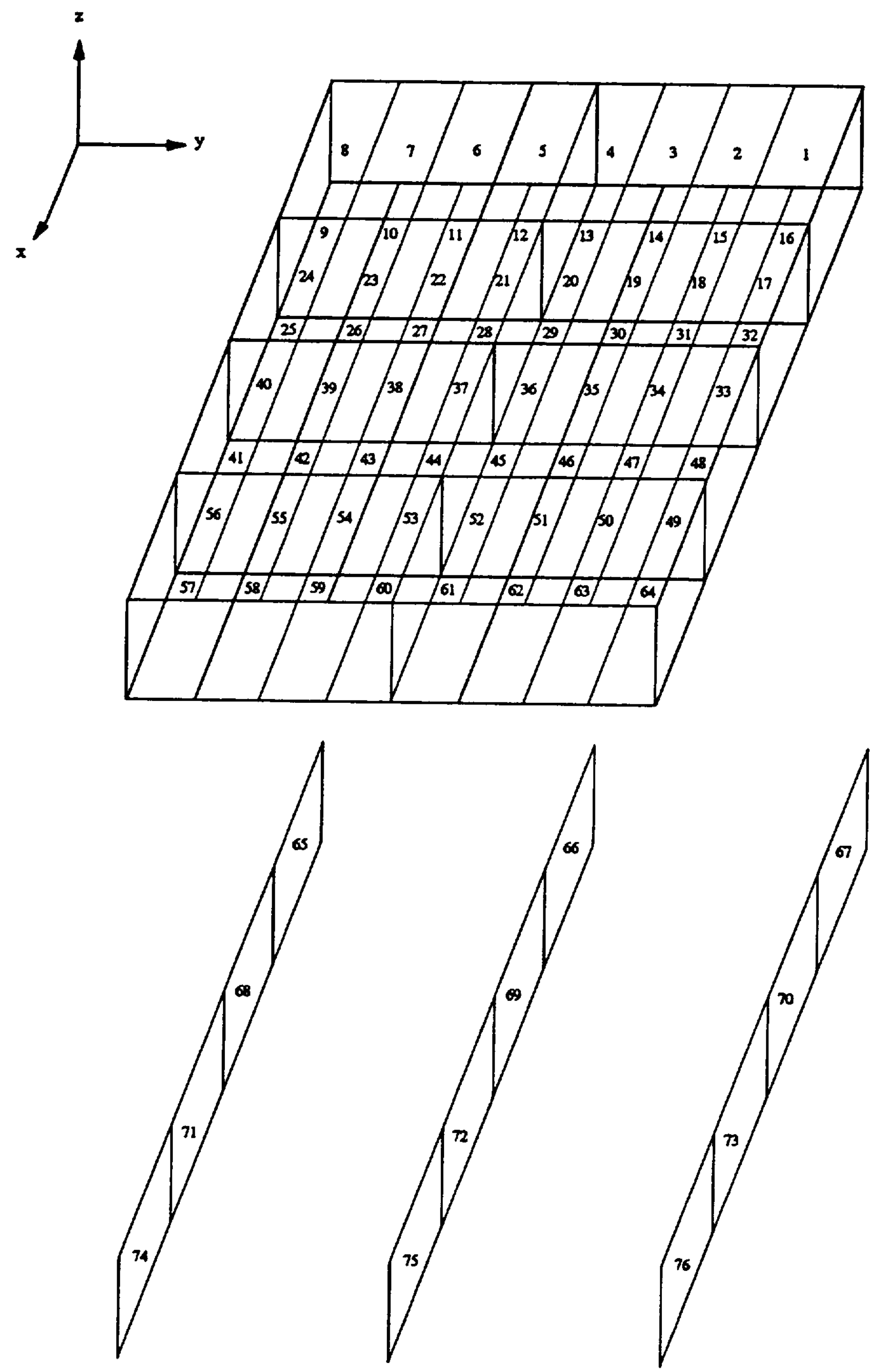
BOTTOM SUPPORTED BUILT-UP STRUCTURE UNDER BENDING & UNIFORM TEMP. LOADINGS
FOR (Si C/Ti-15-3-3-3, TOP:$[90,0]_s$, BOTTOM:$[90]_s$, SPARS:$4[0]_s$); 0.4 FIBER VOLUME RATIO

FINITE ELEMENT MESH SHOWING NODE NUMBERS



BOTTOM SUPPORTED BUILT-UP STRUCTURE UNDER BENDING & UNIFORM TEMP. LOADINGS FOR (Si C/Ti-15-3-3-3, TOP:$[90,0]_s$, BOTTOM:$[90]_s$, SPARS:$4[0]_s$); 0.4 FIBER VOLUME RATIO

FINITE ELEMENT MESH SHOWING ELEMENT NUMBERS



INPUT DECK SETUP FOR PROBLEM # 5

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FILE: UNNUSCF  DEMO     A                  VM/SP CONVERSATIONAL MONITOR SYSTEM

TITLE=PROBLEM # 5, STATIC ANALYSIS FOR BUILT-UP STRUCTURE (PANEL),
TITLE=BOTTOM FIXED IN Z-DIRECTION, INTERNAL PRESSURE (2000 PSI),
TITLE=UNIFORM TEMP. OF 1000 F (REFERENCE TEMP. = 70 F),
TITLE=L=.5", W=.2", H=.075", 3 SPARS-.02"-4(0), TOP-.02"-(90/0/0/90),
TITLE=BOTTOM-.01"-2(90), 4X8 TOP/ BOTTOM & 4X1 SPARS MESH, NO EFFECTS.
HPLATE
PLATE
PROFILE
PLYORDER
TEMPERATURE
PRESSURE
PANEL
ENDOPTION
   2
   2   2   3   7
   2
   3   3
   1   1   1   2   5  10
     1.0
   0
   0
   8
   1   1   1
   2  0.00
     0.000        .02      0.000        .02     0.000        .02
   2  0.25
     0.000        .02      0.000        .02     0.000        .02
      0.50
     0.000        .02      0.000        .02     0.000        .02
   3   3   3
   3   3   3
    0.0000   -0.1000    0.0400    0.0200
    0.0000    0.0000    0.0400    0.0200
    0.0000    0.1000    0.0400    0.0200
    0.2500   -0.1000    0.0400    0.0200
    0.2500    0.0000    0.0400    0.0200
    0.2500    0.1000    0.0400    0.0200
    0.5000   -0.1000    0.0400    0.0200
    0.5000    0.0000    0.0400    0.0200
    0.5000    0.1000    0.0400    0.0200
    0.0000   -0.1000   -0.0350    0.0100
    0.0000    0.0000   -0.0350    0.0100
    0.0000    0.1000   -0.0350    0.0100
```

INPUT DECK SETUP FOR PROBLEM # 5 (CONTINUED)

FILE: UNNUSCF DEMO A VM/SP CONVERSATIONAL MONITOR SYSTEM

```
    0.2500   -0.1000   -0.0350    0.0100
    0.2500    0.0000   -0.0350    0.0100
    0.2500    0.1000   -0.0350    0.0100
    0.5000   -0.1000   -0.0350    0.0100
    0.5000    0.0000   -0.0350    0.0100
    0.5000    0.1000   -0.0350    0.0100
       0.0       0.0       0.0     100.0       0.0     100.0
SICA TI15     .00500       0.0      0.40       0.0
       0.0       0.0       0.0     100.0       0.0     100.0
SICA TI15     .00500       0.0      0.40      90.0
   2    1
         0.
     1000.     1000.      000.     2000.
     1000.     1000.      000.     2000.
     1000.     1000.      000.     2000.
     1000.     1000.      000.     2000.
     1000.     1000.      000.     2000.
     1000.     1000.      000.     2000.
     1000.     1000.      000.     2000.
     1000.     1000.      000.     2000.
     1000.     1000.      000.     2000.
     1000.     1000.     2000.      000.
     1000.     1000.     2000.      000.
     1000.     1000.     2000.      000.
     1000.     1000.     2000.      000.
     1000.     1000.     2000.      000.
     1000.     1000.     2000.      000.
     1000.     1000.     2000.      000.
     1000.     1000.     2000.      000.
     1000.     1000.     2000.      000.
  37   46    9    1
  45   54    9    1
  41   50    9    2
  10   18    1    3
  28   36    1    3
  46   54    1    3
  64   72    1    3
  82   90    1    3
   1  120
   1  120
  79   79
   1    1    4    4
        0.
```

SAMPLE OUTPUT FOR PROBLEM # 5

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 90 DEG. AT TOP)

FILE: UNNUSCF OUT A1 VM/SP CONVERSATIONAL MONITO PAGE 00001

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
12	-0.764E-03	-0.147E-03	0.365E-30	-0.628E-04	0.467E-04	0.123E-04

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 3

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.496E+04	-0.510E+04	0.000E+00	0.396E+02	0.285E+03	-0.207E+02
2	0.227E+04	-0.459E+04	0.000E+00	0.612E+01	0.443E+02	0.612E+03
3	0.267E+04	-0.394E+03	0.000E+00	0.519E+02	0.443E+02	0.612E+03
4	0.154E+05	-0.283E+04	0.000E+00	-0.976E+02	0.285E+03	-0.207E+02

NODE # 3

MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 0.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+
2	SIGF11	0.5309E+05	SIGM11A	-0.9806E+04	SIGD11B	0.8536E+04	SIGL11	0.1535E+05
3	SIGF22	0.1189E+05	SIGM22A	-0.2817E+05	SIGD22B	-0.2810E+05	SIGL22	-0.2832E+04
4	SIGF12	-0.6134E+03	SIGM22B	-0.2813E+05	SIGD22C	0.1189E+05	SIGL33	0.0000E+00
5	SIGF23	0.1313E+03	SIGM22C	0.1189E+05	SIGD12B	-0.3136E+03	SIGL12	-0.9762E+02
6	SIGF13	-0.1794E+04	SIGM12A	-0.5900E+02	SIGD12C	-0.3667E+03	SIGL23	-0.2855E+03
7	SIGF33	0.1299E+05	SIGM12B	-0.1027E+03	SIGD23B	0.6713E+02	SIGL13	0.2067E+02
8			SIGM12C	-0.1201E+03	SIGD23C	0.7851E+02		
9			SIGM23A	0.1263E+02	SIGD13B	-0.9169E+03		
10			SIGM23B	0.2198E+02	SIGD13C	-0.1072E+04		
11			SIGM23C	0.2571E+02	SIGD33B	-0.2718E+05		
12			SIGM13A	-0.1725E+03	SIGD33C	0.1299E+05		
13			SIGM13B	-0.3002E+03	SIGD11C	0.8536E+04		
14			SIGM13C	-0.3511E+03				
15			SIGM33A	-0.2759E+05				
16			SIGM33B	-0.2718E+05				
17			SIGM33C	0.1299E+05				
18			SIGM11B	-0.9806E+04				
19			SIGM11C	-0.9806E+04				

TIME REQUIRED TO CARRY OUT THE ANALYSIS 0.125 SEC.
TIME REQUIRED TO : READ IN DATA 0.019 SEC.
DO PREPROCESSING 0.100 SEC.

DEMONSTRATION PROBLEM NO. 6

PROBLEM TYPE:

Buckling analysis of a solid curved panel type structure using plate element subjected to mechanical loading.

PROBLEM DESCRIPTION:

A curved panel (20 degree segment) of 6" radius, 2" width, and 0.125" thickness with both straight edges clamped and both curved edges free, is subjected to an external pressure load of 20 psi at the top surface. The curved panel is made of Sic/Ti-15-3-3-3 composite material (Silicon Carbide fiber, Titanium matrix with 15% Vanadium, 3% Aluminum, 3% Chromium, and 3% Tin, and interphase with average properties of fiber and matrix). The composite laminate consists of 4 (0/45/-45/90) plies of equal thickness with 0.4 fiber volume ratio. The ply lay-up is such that the 0 degree ply is at the top and the 90 degree at the bottom of the curved panel. The ply lay-up is same as that used for problem # 4 shown on page 26. The material properties at the reference temperature of 70 F are listed in Table II. The exponents for material property variations according to the nonlinear multi-factor interaction model (Ref. 1) are listed in Table III. The geometry, boundary conditions, loading, and ply lay-up are shown in the figure on next page.

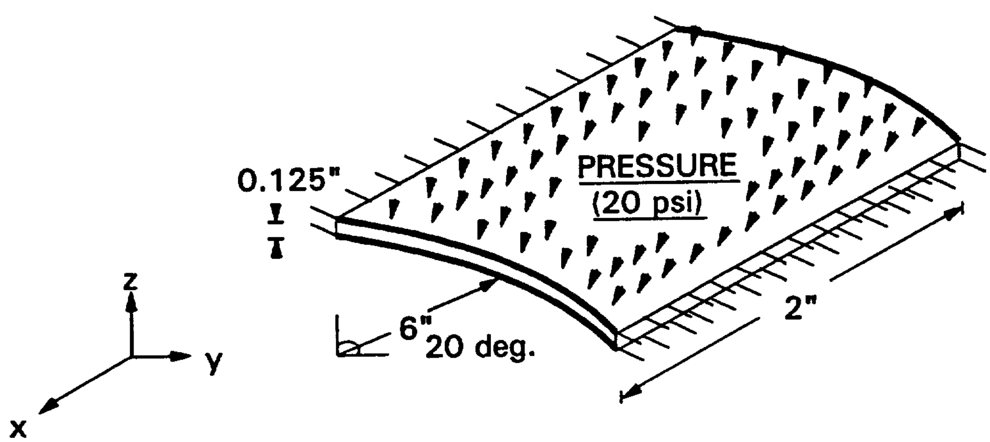
MODELING HINTS:

The finite element mesh consists of 8 elements in the x-direction and 8 along the curved edge (IU = 9 and JU = 9 on card group # 3). The mesh is same as that used for problem # 4 shown on page 27. The material property data file, "DATA BANK" is included in Appendix 1.

PROBLEM # 6

BUCKLING OF FIXED-FREE CURVED PANEL UNDER EXTERNAL PRESSURE LOADING FOR (Si C/Ti-15-3-3-3, 0/±45/90); 0.4 FIBER VOLUME RATIO

GEOMETRY, BOUNDARY CONDITIONS, AND LOADING



INPUT DECK SETUP FOR PROBLEM # 6

```
FILE: SNNUBMF   DEMO    A1                VM/SP CONVERSATIONAL MONITOR

 TITLE=PROBLEM # 6, BUCKLING ANALYSIS FOR CURVED PANEL (20 deg. SHELL
 TITLE=ROOF- MECH. LOAD ONLY), FIXED STRAIGHT EDGES, FREE CURVED EDGES
 TITLE=EXTERNAL PRESSURE (20 PSI), NO THERMAL LOAD,
 TITLE=R=6", W=2", T=0.125", 4(0/45/-45/90)PLIES, FVR=.4, 8X8 MESH
 TITLE=NO FABRICATION EFFECTS, NO FIBER DEGRADATION EFFECTS.
 SPLATE
 PLATE
 PRESSURE
 BUCKLING
 PLYORDER
 UNSYMMETRICAL
 ENDOPTION
    4
    2
    4   9   9   4
       0.       2.
    2
    2
    2   1   1   1   5  10
      1.0
    1   0  40
    0
   11
    5   5
    8
       0. -1.0420  5.9100  0.1250
       0. -0.5230  5.9775  0.1250
       0.      0.  6.0000  0.1250
       0.  0.5230  5.9775  0.1250
       0.  1.0420  5.9100  0.1250
    0
       2. -1.0420  5.9100  0.1250
       2. -0.5230  5.9775  0.1250
       2.      0.  6.0000  0.1250
       2.  0.5230  5.9775  0.1250
       2.  1.0420  5.9100  0.1250
        0.0     100.0       0.0     100.0       0.0     100.0
 SICA TI15    0.03125       0.0      0.40       0.0
        0.0     100.0       0.0     100.0       0.0     100.0
 SICA TI15    0.03125       0.0      0.40      45.0
        0.0     100.0       0.0     100.0       0.0     100.0
 SICA TI15    0.03125       0.0      0.40     -45.0
        0.0     100.0       0.0     100.0       0.0     100.0
```

INPUT DECK SETUP FOR PROBLEM # 6 (CONTINUED)

```
FILE: SNNUBMF   DEMO    A1                VM/SP CONVERSATIONAL MONITOR

SICA TI15    0.03125      0.0       0.40       90.0
   4   3
   1   2
         0.        180.
        70.         70.       0.0        0.
        70.         70.       0.0        0.
        70.         70.       0.0        0.
        70.         70.       0.0        0.
        70.         70.       0.0        0.
        70.         70.       0.0        0.
        70.         70.       0.0        0.
        70.         70.       0.0        0.
        70.         70.       0.0        0.
        70.         70.       0.0        0.
        70.         70.       0.0       20.
        70.         70.       0.0       20.
        70.         70.       0.0       20.
        70.         70.       0.0       20.
        70.         70.       0.0       20.
        70.         70.       0.0       20.
        70.         70.       0.0       20.
        70.         70.       0.0       20.
        70.         70.       0.0       20.
        70.         70.       0.0       20.
   1  73   9   2
   1  73   9   3
   1  73   9   4
   1  73   9   5
   1  73   9   6
   9  81   9   2
   9  81   9   3
   9  81   9   4
   9  81   9   5
   9  81   9   6
  37  45   8   1
   1  81
   1  81
   1   1   5   5
   1   1
        0.0        180.0
        0.0        180.0
```

SAMPLE OUTPUT FOR PROBLEM # 6

FILE: SNNUBMF OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

INPUT TEMPERATURE & PRESSURE

TEMPERATURE		PRESSURE	
UPPER	LOWER	UPPER	LOWER
70.000	70.000	20.000	0.000
70.000	70.000	20.000	0.000
70.000	70.000	20.000	0.000
70.000	70.000	20.000	0.000
70.000	70.000	20.000	0.000
70.000	70.000	20.000	0.000
70.000	70.000	20.000	0.000
70.000	70.000	20.000	0.000
70.000	70.000	20.000	0.000
70.000	70.000	20.000	0.000

EIGENVALUE NUMBER 1 VALUE = 0.194259E+04

TIME REQUIRED TO CARRY OUT THE ANALYSIS 223.331 SEC.
TIME REQUIRED TO : READ IN DATA 0.017 SEC.
DO PREPROCESSING 0.101 SEC.

DEMONSTRATION PROBLEM NO. 7

PROBLEM TYPE:

Buckling analysis of a hollow sandwich type built-up structure using plate element subjected to mechanical loading.

PROBLEM DESCRIPTION:

A hollow built-up structure of 0.5" length, 0.2" width, 0.075" total thickness, 0.02" thickness of top plate, 0.01" thickness of bottom plate, and 3 spars in the x-z plane equally spaced in the y-direction with 0.02" thickness the z-direction, with 2 long edges simply supported and 2 short edges free, is subjected to distributed axial load of 100 lb/inch on each simply supported edge. The built-up structure is made of Sic/Ti-15-3-3-3 composite material (Silicon Carbide fiber, Titanium matrix with 15% Vanadium, 3% Aluminum, 3% Chromium, and 3% Tin, and interphase with average properties of fiber and matrix). The composite laminate consists of 4 (90/0/0/90) plies of equal thickness for the top plate, 2 (90/90) plies of equal thickness for the bottom plate, and 4 (0/0/0/0) plies of equal thickness for the spars, all with 0.4 fiber volume ratio. The ply lay-up is symmetric for all parts of the structure. The ply lay-up is same as that used for problem # 5 shown on pages 33-34. The material properties at the reference temperature of 70 F are listed in Table II. The exponents for material property variations according to the nonlinear multi-factor interaction model (Ref. 1) are listed in Table III. The geometry, boundary conditions, loading, and ply lay-up are shown in the figure on next page.

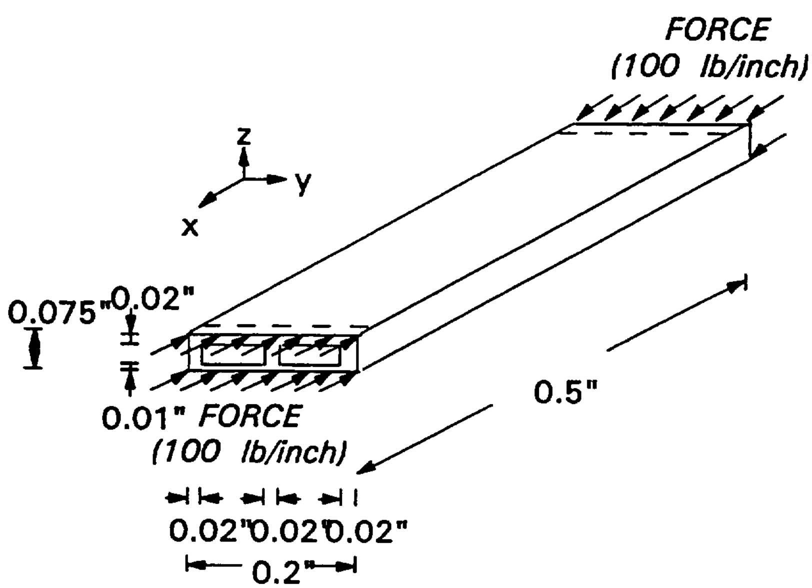
MODELING HINTS:

The finite element mesh consists of 4 elements in the x-direction and 8 in the y-direction for both the top and bottom plates and 4 elements in the x-direction and 1 element in the z-direction for all each of the 3 spars. The mesh is same as that used for problem # 5 shown on pages 35-36. The material property data file, "DATA BANK" is included in Appendix 1.

PROBLEM # 7

BUCKLING OF SIMPLY SUPPORTED-FREE BUILT-UP STRUCTURE UNDER AXIAL LOADING
FOR (Si C/Ti-15-3-3-3, TOP:$[90,0]_s$, BOTTOM:$[90]_s$, SPARS:$4[0]_s$); 0.4 FIBER VOLUME RATIO

GEOMETRY, BOUNDARY CONDITIONS, AND LOADING



INPUT DECK SETUP FOR PROBLEM # 7

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FILE: UNNUBMF    DEMO     A1                    VM/SP CONVERSATIONAL MONITOR

 TITLE=PROBLEM # 7, BUCKLING ANALYSIS FOR BUILT-UP STRUCTURE (PANEL-
 TITLE=MECH. LOAD ONLY), S.S. AT 2 SHORTER EDGES, DISTRIBUTED AXIAL
 TITLE=COMPRESSIVE LOAD (1000 LB/INCH) ON 2 SHORTER EDGES,NO THERMAL L
 TITLE=L=.5", W=.2", H=.075", 3 SPARS-.02"-4(0), TOP-.02"-(90/0/0/90),
 TITLE=BOTTOM-.01"-2(90), 4X8 TOP/ BOTTOM & 4X1 SPARS MESH, NO EFFECTS
 HPLATE
 PLATE
 PROFILE
 PLYORDER
 FORCE
 PANEL
 BUCKLING
 ENDOPTION
    2
    2    2    3    7
    2
    3    3
    2    1    1    1   10   10
      1.0
    1    0   40
   36
    8
    1    1    1
    2   0.00
      0.000        .02       0.000        .02       0.000        .02
    2   0.25
      0.000        .02       0.000        .02       0.000        .02
        0.50
      0.000        .02       0.000        .02       0.000        .02
    3    3    3
    3    3    3
      0.0000    -0.1000     0.0400     0.0200
      0.0000     0.0000     0.0400     0.0200
      0.0000     0.1000     0.0400     0.0200
      0.2500    -0.1000     0.0400     0.0200
      0.2500     0.0000     0.0400     0.0200
      0.2500     0.1000     0.0400     0.0200
      0.5000    -0.1000     0.0400     0.0200
      0.5000     0.0000     0.0400     0.0200
      0.5000     0.1000     0.0400     0.0200
      0.0000    -0.1000    -0.0350     0.0100
      0.0000     0.0000    -0.0350     0.0100
      0.0000     0.1000    -0.0350     0.0100
```

INPUT DECK SETUP FOR PROBLEM # 7 (CONTINUED)

```
 FILE: UNNUBMF   DEMO    A1               VM/SP CONVERSATIONAL MONITOR
       0.2500   -0.1000   -0.0350    0.0100
       0.2500    0.0000   -0.0350    0.0100
       0.2500    0.1000   -0.0350    0.0100
       0.5000   -0.1000   -0.0350    0.0100
       0.5000    0.0000   -0.0350    0.0100
       0.5000    0.1000   -0.0350    0.0100
       0.0       0.0       0.0      100.0        0.0      100.0
SICA TI15     .00500       0.0       0.40        0.0
       0.0       0.0       0.0      100.0        0.0      100.0
SICA TI15     .00500       0.0       0.40       90.0
   2    1
        0.      180.
   1    1
      1.25       2.5
   2    1
       2.5       5.0
   3    1
       2.5       5.0
   4    1
       2.5       5.0
   5    1
       2.5       5.0
   6    1
       2.5       5.0
   7    1
       2.5       5.0
   8    1
       2.5       5.0
   9    1
      1.25       2.5
  10    1
      1.25       2.5
  11    1
       2.5       5.0
  12    1
       2.5       5.0
  13    1
       2.5       5.0
  14    1
       2.5       5.0
  15    1
       2.5       5.0
  16    1
       2.5       5.0
```

INPUT DECK SETUP FOR PROBLEM # 7 (CONTINUED)

```
FILE: UNNUBMF   DEMO    A1                    VM/SP CONVERSATIONAL MONITOR
   17    1
         2.5       5.0
   18    1
        1.25       2.5
   73    1
       -1.25      -2.5
   74    1
        -2.5      -5.0
   75    1
        -2.5      -5.0
   76    1
        -2.5      -5.0
   77    1
        -2.5      -5.0
   78    1
        -2.5      -5.0
   79    1
        -2.5      -5.0
   80    1
        -2.5      -5.0
   81    1
       -1.25      -2.5
   82    1
       -1.25      -2.5
   83    1
        -2.5      -5.0
   84    1
        -2.5      -5.0
   85    1
        -2.5      -5.0
   86    1
        -2.5      -5.0
   87    1
        -2.5      -5.0
   88    1
        -2.5      -5.0
   89    1
        -2.5      -5.0
   90    1
      - 1.25      -2.5
    1   18    1    3
    1   18    1    4
    1   18    1    6
```

```
73  90   1   3
73  90   1   4
73  90   1   6
41  50   9   2
41  50   9   1
37  90
37  90
 3   3  12  12
 4   4
       0.        180.
       0.        180.
```

SAMPLE OUTPUT FOR PROBLEM # 7

```
FILE: UNNUBMF  OUT    A                VM/SP CONVERSATIONAL MONITOR SYSTEM                PAGE 00001

          CONCENTRATED FORCE DATA

  NODE NUMBER     1
  DIRECTION OF FORCE     1

     0.0000000                 1.250

   180.0000000                 2.500


  NODE NUMBER     2
  DIRECTION OF FORCE     1

     0.0000000                 2.500

   180.0000000                 5.000


  NODE NUMBER     3
  DIRECTION OF FORCE     1

     0.0000000                 2.500

   180.0000000                 5.000


  NODE NUMBER     4
  DIRECTION OF FORCE     1

     0.0000000                 2.500

   180.0000000                 5.000
```

SAMPLE OUTPUT FOR PROBLEM # 7 (CONTINUED)

FILE: UNNUBMF OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

NODE NUMBER 5
DIRECTION OF FORCE 1

0.0000000	2.500
180.0000000	5.000

NODE NUMBER 6
DIRECTION OF FORCE 1

0.0000000	2.500
180.0000000	5.000

NODE NUMBER 7
DIRECTION OF FORCE 1

0.0000000	2.500
180.0000000	5.000

NODE NUMBER 8
DIRECTION OF FORCE 1

0.0000000	2.500
180.0000000	5.000

NODE NUMBER 9
DIRECTION OF FORCE 1

0.0000000	1.250
180.0000000	2.500

NODE NUMBER 10
DIRECTION OF FORCE 1

0.0000000	1.250
180.0000000	2.500

SAMPLE OUTPUT FOR PROBLEM # 7 (CONTINUED)

```
FILE: UNMUBMF  OUT     A              VM/SP CONVERSATIONAL MONITOR SYSTEM                    PAGE 00001
 NODE NUMBER   11
 DIRECTION OF FORCE    1

   0.0000000            2.500

  180.0000000           5.000


 NODE NUMBER   12
 DIRECTION OF FORCE    1

   0.0000000            2.500

  180.0000000           5.000

 NODE NUMBER   13
 DIRECTION OF FORCE    1

   0.0000000            2.500

  180.0000000           5.000


 NODE NUMBER   14
 DIRECTION OF FORCE    1

   0.0000000            2.500

  180.0000000           5.000


 NODE NUMBER   15
 DIRECTION OF FORCE    1

   0.0000000            2.500

  180.0000000           5.000


 NODE NUMBER   16
 DIRECTION OF FORCE    1

   0.0000000            2.500

  180.0000000           5.000
```

SAMPLE OUTPUT FOR PROBLEM # 7 (CONTINUED)

FILE: UNNUBMF OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

NODE NUMBER 17
DIRECTION OF FORCE 1

0.0000000	2.500
180.0000000	5.000

NODE NUMBER 18
DIRECTION OF FORCE 1

0.0000000	1.250
180.0000000	2.500

NODE NUMBER 73
DIRECTION OF FORCE 1

0.0000000	-1.250
180.0000000	-2.500

NODE NUMBER 74
DIRECTION OF FORCE 1

0.0000000	-2.500
180.0000000	-5.000

NODE NUMBER 75
DIRECTION OF FORCE 1

0.0000000	-2.500
180.0000000	-5.000

NODE NUMBER 76
DIRECTION OF FORCE 1

0.0000000	-2.500
180.0000000	-5.000

SAMPLE OUTPUT FOR PROBLEM # 7 (CONTINUED)

NODE NUMBER 77
DIRECTION OF FORCE 1

0.0000000	-2.500
180.0000000	-5.000

NODE NUMBER 78
DIRECTION OF FORCE 1

0.0000000	-2.500
180.0000000	-5.000

NODE NUMBER 79
DIRECTION OF FORCE 1

0.0000000	-2.500
180.0000000	-5.000

NODE NUMBER 80
DIRECTION OF FORCE 1

0.0000000	-2.500
180.0000000	-5.000

NODE NUMBER 81
DIRECTION OF FORCE 1

0.0000000	-1.250
180.0000000	-2.500

NODE NUMBER 82
DIRECTION OF FORCE 1

0.0000000	-1.250
180.0000000	-2.500

SAMPLE OUTPUT FOR PROBLEM # 7 (CONTINUED)

FILE: UNNUBMF OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

NODE NUMBER 83
DIRECTION OF FORCE 1

0.0000000	-2.500
180.0000000	-5.000

NODE NUMBER 84
DIRECTION OF FORCE 1

0.0000000	-2.500
180.0000000	-5.000

NODE NUMBER 85
DIRECTION OF FORCE 1

0.0000000	-2.500
180.0000000	-5.000

NODE NUMBER 86
DIRECTION OF FORCE 1

0.0000000	-2.500
180.0000000	-5.000

NODE NUMBER 87
DIRECTION OF FORCE 1

0.0000000	-2.500
180.0000000	-5.000

NODE NUMBER 88
DIRECTION OF FORCE 1

0.0000000	-2.500
180.0000000	-5.000

SAMPLE OUTPUT FOR PROBLEM # 7 (CONTINUED)

```
FILE: UNNUBMF  OUT     A                  VM/SP CONVERSATIONAL MONITOR SYSTEM                     PAGE 00001

   NODE NUMBER    89
   DIRECTION OF FORCE    1

      0.0000000               -2.500

    180.0000000               -5.000


   NODE NUMBER    90
   DIRECTION OF FORCE    1

      0.0000000               -1.250

    180.0000000               -2.500


 EIGENVALUE NUMBER     1 VALUE =     0.313609E+02
TIME REQUIRED TO CARRY OUT THE ANALYSIS                              268.824 SEC.
TIME REQUIRED TO : READ IN DATA                                        0.026 SEC.
                   DO PREPROCESSING                                    0.112 SEC.
```

DEMONSTRATION PROBLEM NO. 8

PROBLEM TYPE:

Buckling analysis of a solid curved panel type structure using plate element subjected to mechanical loading including fiber degradation.

PROBLEM DESCRIPTION:

A curved panel (20 degree segment) of 6" radius, 2" width, and 0.125" thickness with both straight edges clamped and both curved edges free, is subjected to an external pressure load of 20 psi at the top surface. The curved panel is made of Sic/Ti-15-3-3-3 composite material (Silicon Carbide fiber, Titanium matrix with 15% Vanadium, 3% Aluminum, 3% Chromium, and 3% Tin, and interphase with average properties of fiber and matrix). The composite laminate consists of 4 (0/45/-45/90) plies of equal thickness with 0.4 fiber volume ratio. The ply lay-up is such that the 0 degree ply is at the top and the 90 degree at the bottom of the curved panel. The ply lay-up is same as that used for problem # 4 shown on page 26. The material properties at the reference temperature of 70 F are listed in Table II. The exponents for material property variations according to the nonlinear multi-factor interaction model (Ref. 1) are listed in Table III. The fiber is degraded by an amount equal to 10 % of the fiber diameter, creating an interphase between the fiber and matrix. The geometry, boundary conditions, loading, and ply lay-up are shown in the figure on next page.

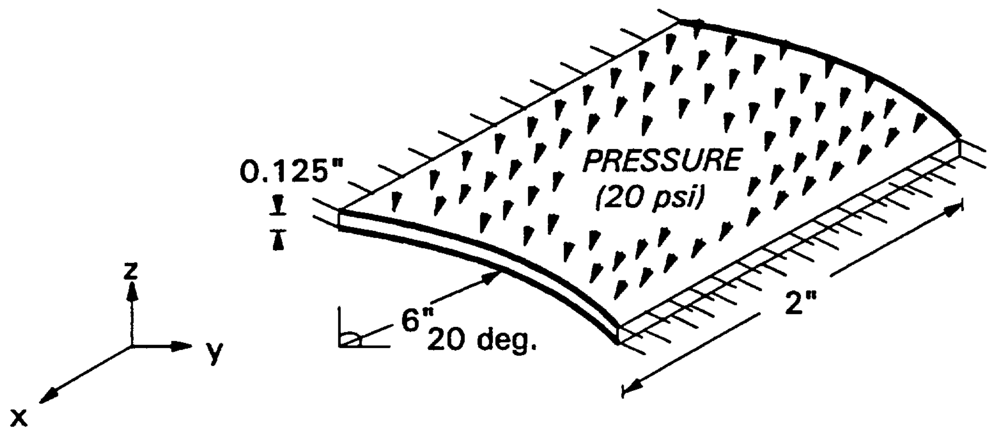
MODELING HINTS:

The finite element mesh consists of 8 elements in the x-direction and 8 along the curved edge (IU = 9 and JU = 9 on card group # 3). The mesh is same as that used for problem # 4 shown on page 27. The material property data file, "DATA BANK" is included in Appendix 1.

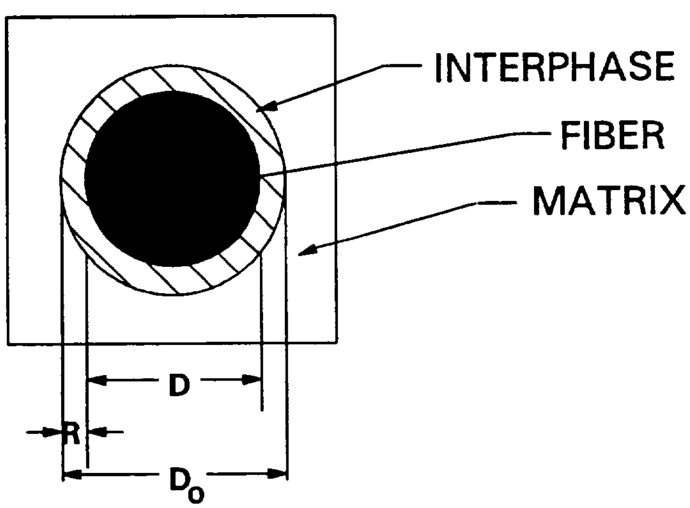
PROBLEM # 8

BUCKLING OF FIXED-FREE CURVED PANEL UNDER EXTERNAL PRESSURE LOADING WITH FIBER DEGRADATION, GIVING RISE TO AN INTERPHASE BETWEEN MATRIX & FIBER FOR (Si C/Ti-15-3-3-3, 0/±45/90); 0.4 FIBER VOLUME RATIO

GEOMETRY, BOUNDARY CONDITIONS, AND LOADING



FIBER DEGRADATION BY 10 % OF ITS DIAMETER



D_o : Original Fiber Diameter (0.0056 inch)

D : Reduced Fiber Diameter (0.00504 inch)

R : Reduction in Fiber Diameter (by 10 %, i.e., by 0.00056 inch)

INPUT DECK SETUP FOR PROBLEM # 8

```
FILE: SNYUBMF   DEMO    A1                    VM/SP CONVERSATIONAL MONITOR

TITLE=PROBLEM # 8, BUCKLING ANALYSIS FOR CURVED PANEL (20 deg. SHELL
TITLE=ROOF- MECH. LOAD ONLY), FIXED STRAIGHT EDGES, FREE CURVED EDGES,
TITLE=EXTERNAL PRESSURE (20 PSI), NO THERMAL LOAD,
TITLE=R=6", W=2", T=0.125", 4(0/45/-45/90)PLIES, FVR=.4, 8X8 MESH
TITLE=NO FABRICATION EFFECTS, FIBER DEGRADATION EFFECTS INCLUDED.
SPLATE
PLATE
INTERFACE
PRESSURE
BUCKLING
PLYORDER
UNSYMMETRICAL
ENDOPTION
   4
   2
   4   9   9   4
     0.       2.
   2
   2
   2   1   1   1   5  10
    1.0
   1   0  40
   0
  11
    0.1
   5   5
   8
     0. -1.0420  5.9100  0.1250
     0. -0.5230  5.9775  0.1250
     0.      0.  6.0000  0.1250
     0.  0.5230  5.9775  0.1250
     0.  1.0420  5.9100  0.1250
   0
     2. -1.0420  5.9100  0.1250
     2. -0.5230  5.9775  0.1250
     2.      0.  6.0000  0.1250
     2.  0.5230  5.9775  0.1250
     2.  1.0420  5.9100  0.1250
      0.0      100.0       0.0      100.0       0.0      100.0
SICA TI15   0.03125        0.0       0.40       0.0
      0.0      100.0       0.0      100.0       0.0      100.0
SICA TI15   0.03125        0.0       0.40      45.0
      0.0      100.0       0.0      100.0       0.0      100.0
SICA TI15   0.03125        0.0       0.40     -45.0
      0.0      100.0       0.0      100.0       0.0      100.0
```

INPUT DECK SETUP FOR PROBLEM # 8 (CONTINUED)

```
FILE: SNYUBMF   DEMO    A1                VM/SP CONVERSATIONAL MONITOR

SICA TI15   0.03125      0.0       0.40       90.0
   4   3
   1   2
      0.      180.
      70.      70.      0.0       0.
      70.      70.      0.0       0.
      70.      70.      0.0       0.
      70.      70.      0.0       0.
      70.      70.      0.0       0.
      70.      70.      0.0       0.
      70.      70.      0.0       0.
      70.      70.      0.0       0.
      70.      70.      0.0       0.
      70.      70.      0.0       0.
      70.      70.      0.0      20.
      70.      7C.      0.0      20.
      70.      70.      0.0      20.
      70.      70.      0.0      20.
      70.      70.      0.0      20.
      70.      70.      0.0      20.
      70.      70.      0.0      20.
      70.      70.      0.0      20.
      70.      70.      0.0      20.
      70.      70.      0.0      20.
  1  73   9   2
  1  73   9   3
  1  73   9   4
  1  73   9   5
  1  73   9   6
  9  81   9   2
  9  81   9   3
  9  81   9   4
  9  81   9   5
  9  81   9   6
 37  45   8   1
  1  81
  1  81
  1   1   5   5
  1   1
     0.0      180.0
     0.0      180.0
```

SAMPLE OUTPUT FOR PROBLEM # 8

FILE: SNYUBMF OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

THE INTERFACE THICKNESS IS 0.1000 PERCENT OF THE FIBER DIAMETER

INPUT TEMPERATURE & PRESSURE

TEMPERATURE		PRESSURE	
UPPER	LOWER	UPPER	LOWER
70.000	70.000	20.000	0.000
70.000	70.000	20.000	0.000
70.000	70.000	20.000	0.000
70.000	70.000	20.000	0.000
70.000	70.000	20.000	0.000
70.000	70.000	20.000	0.000
70.000	70.000	20.000	0.000
70.000	70.000	20.000	0.000
70.000	70.000	20.000	0.000
70.000	70.000	20.000	0.000

EIGENVALUE NUMBER 1 VALUE = 0.180580E+04

TIME REQUIRED TO CARRY OUT THE ANALYSIS 224.284 SEC.

TIME REQUIRED TO : READ IN DATA 0.017 SEC.
DO PREPROCESSING 0.101 SEC.

DEMONSTRATION PROBLEM NO. 9

PROBLEM TYPE:

Buckling analysis of a hollow sandwich type built-up structure using plate element subjected to mechanical loading including fiber degradation.

PROBLEM DESCRIPTION:

A hollow built-up structure of 0.5" length, 0.2" width, 0.075" total thickness, 0.02" thickness of top plate, 0.01" thickness of bottom plate, and 3 spars in the x-z plane equally spaced in the y-direction with 0.02" thickness the z-direction, with 2 long edges simply supported and 2 short edges free, is subjected to distributed axial load of 100 lb/inch on each simply supported edge. The built-up structure is made of Sic/Ti-15-3-3-3 composite material (Silicon Carbide fiber, Titanium matrix with 15% Vanadium, 3% Aluminum, 3% Chromium, and 3% Tin, and interphase with average properties of fiber and matrix). The composite laminate consists of 4 (90/0/0/90) plies of equal thickness for the top plate, 2 (90/90) plies of equal thickness for the bottom plate, and 4 (0/0/0/0) plies of equal thickness for the spars, all with 0.4 fiber volume ratio. The ply lay-up is symmetric for all parts of the structure. The ply lay-up is same as that used for problem # 5 shown on pages 33-34. The material properties at the reference temperature of 70 F are listed in Table II. The exponents for material property variations according to the nonlinear multi-factor interaction model (Ref. 1) are listed in Table III. The fiber is degraded by an amount equal to 10 % of the fiber diameter, creating an interphase between the fiber and matrix. The geometry, boundary conditions, loading, and ply lay-up are shown in the figure on next page.

MODELING HINTS:

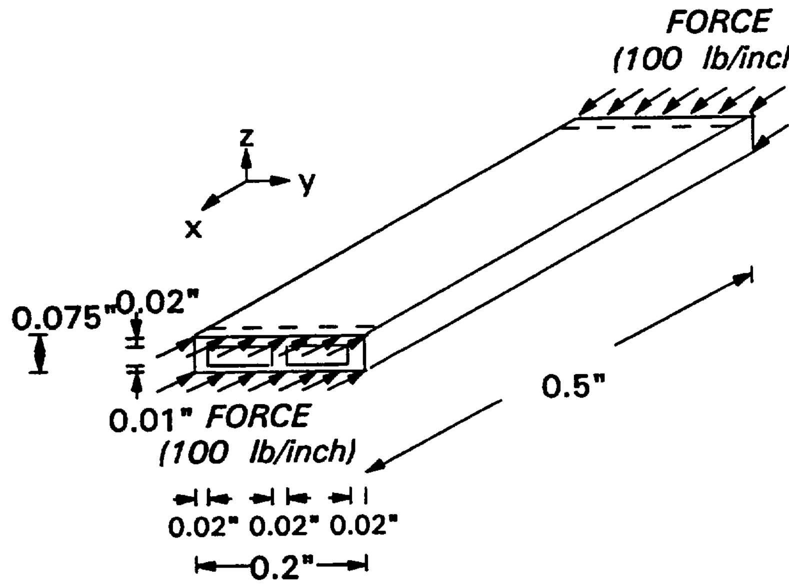
The finite element mesh consists of 4 elements in the x-direction and 8 in the y-direction for both the top and bottom plates and 4 elements in the x-direction and 1 element in the z-direction for all each of the 3 spars. The mesh is same as that used for problem # 5 shown on pages 35-36. The material property data file, "DATA BANK" is included in Appendix 1.

PROBLEM # 9

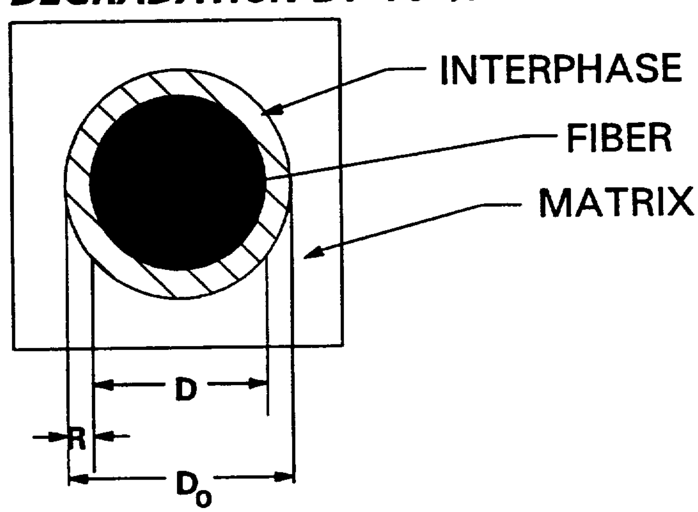
BUCKLING OF SIMPLY SUPPORTED-FREE BUILT-UP STRUCTURE UNDER AXIAL LOADING WITH FIBER DEGRADATION, GIVING RISE TO AN INTERPHASE BETWEEN MATRIX & FIBER

FOR (Si C/Ti-15-3-3-3, TOP:$[90,0]_s$, BOTTOM:$[90]_s$, SPARS:$4[0]_s$); 0.4 FIBER VOLUME RATIO

GEOMETRY, BOUNDARY CONDITIONS, AND LOADING



FIBER DEGRADATION BY 10 % OF ITS DIAMETER



D_0 : Original Fiber Diameter (0.0056 inch)

D : Reduced Fiber Diameter (0.00504 inch)

R : Reduction in Fiber Diameter (by 10 %, i.e., by 0.00056 inch)

INPUT DECK SETUP FOR PROBLEM # 9

```
FILE: UNYUBMF   DEMO    A1                  VM/SP CONVERSATIONAL MONITOR

 TITLE=PROBLEM # 9, BUCKLING ANALYSIS FOR BUILT-UP STRUCTURE (PANEL-
 TITLE=MECH. LOAD ONLY), S.S. AT 2 SHORTER EDGES, DISTRIBUTED AXIAL
 TITLE=COMPRESSIVE LOAD (1000 LB/INCH) ON 2 SHORTER EDGES,NO THERMAL L
 TITLE=L=.5", W=.2", H=.075", 3 SPARS-.02"-4(0), TOP-.02"-(90/0/0/90),
 TITLE=BOTTOM-.01"-2(90), 4X8 TOP/ BOTTOM & 4X1 SPARS MESH, Fiber DEG.
 HPLATE
 PLATE
 INTERFACE
 PROFILE
 PLYORDER
 FORCE
 PANEL
 BUCKLING
 ENDOPTION
    2
    2   2   3   7
    2
    3   3
    2   1   1   1  10  10
      1.0
    1   0  40
   36
    8
  0.1
    1   1   1
    2  0.00
      0.000        .02      0.000       .02     0.000       .02
    2  0.25
      0.000        .02      0.000       .02     0.000       .02
       0.50
      0.000        .02      0.000       .02     0.000       .02
    3   3   3
    3   3   3
      0.0000   -0.1000   0.0400   0.0200
      0.0000    0.0000   0.0400   0.0200
      0.0000    0.1000   0.0400   0.0200
      0.2500   -0.1000   0.0400   0.0200
      0.2500    0.0000   0.0400   0.0200
      0.2500    0.1000   0.0400   0.0200
      0.5000   -0.1000   0.0400   0.0200
      0.5000    0.0000   0.0400   0.0200
      0.5000    0.1000   0.0400   0.0200
      0.0000   -0.1000  -0.0350   0.0100
      0.0000    0.0000  -0.0350   0.0100
```

INPUT DECK SETUP FOR PROBLEM # 9 (CONTINUED)

```
 FILE: UNYUBMF   DEMO    A1                   VM/SP CONVERSATIONAL MONITOR
      0.0000    0.1000   -0.0350    0.0100
      0.2500   -0.1000   -0.0350    0.0100
      0.2500    0.0000   -0.0350    0.0100
      0.2500    0.1000   -0.0350    0.0100
      0.5000   -0.1000   -0.0350    0.0100
      0.5000    0.0000   -0.0350    0.0100
      0.5000    0.1000   -0.0350    0.0100
      0.0       0.0       0.0     100.0      0.0      100.0
SICA TI15     .00500      0.0       0.40     0.0
     0.0        0.0       0.0     100.0      0.0      100.0
SICA TI15     .00500      0.0       0.40    90.0
   2   1
       0.       180.
   1   1
     1.25       2.5
   2   1
      2.5       5.0
   3   1
      2.5       5.0
   4   1
      2.5       5.0
   5   1
      2.5       5.0
   6   1
      2.5       5.0
   7   1
      2.5       5.0
   8   1
      2.5       5.0
   9   1
     1.25       2.5
  10   1
     1.25       2.5
  11   1
      2.5       5.0
  12   1
      2.5       5.0
  13   1
      2.5       5.0
  14   1
      2.5       5.0
  15   1
      2.5       5.0
  16   1
      2.5       5.0
```

INPUT DECK SETUP FOR PROBLEM # 9 (CONTINUED)

```
FILE: UNYUBMF    DEMO    A1                    VM/SP CONVERSATIONAL MONITOR
  17    1
         2.5        5.0
  18    1
        1.25        2.5
  73    1
       -1.25       -2.5
  74    1
        -2.5       -5.0
  75    1
        -2.5       -5.0
  76    1
        -2.5       -5.0
  77    1
        -2.5       -5.0
  78    1
        -2.5       -5.0
  79    1
        -2.5       -5.0
  80    1
        -2.5       -5.0
  81    1
       -1.25       -2.5
  82    1
       -1.25       -2.5
  83    1
        -2.5       -5.0
  84    1
        -2.5       -5.0
  85    1
        -2.5       -5.0
  86    1
        -2.5       -5.0
  87    1
        -2.5       -5.0
  88    1
        -2.5       -5.0
  89    1
        -2.5       -5.0
  90    1
      - 1.25       -2.5
   1   18    1    3
   1   18    1    4
   1   18    1    6
  73   90    1    3
  73   90    1    4
```

SAMPLE OUTPUT FOR PROBLEM # 9

FILE: UNYUBMF OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

```
73  90   1   6
41  50   9   2
41  50   9   1
37  90
37  90
 3   3  12  12
 4   4
      0.         180.
      0.         180.
```

CONCENTRATED FORCE DATA

NODE NUMBER 1
DIRECTION OF FORCE 1

0.0000000	1.250
180.0000000	2.500

NODE NUMBER 2
DIRECTION OF FORCE 1

0.0000000	2.500
180.0000000	5.000

NODE NUMBER 3
DIRECTION OF FORCE 1

0.0000000	2.500
180.0000000	5.000

NODE NUMBER 4
DIRECTION OF FORCE 1

0.0000000	2.500
180.0000000	5.000

SAMPLE OUTPUT FOR PROBLEM # 9 (CONTINUED)

FILE: UNYUBMF OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

NODE NUMBER 5
DIRECTION OF FORCE 1

0.0000000	2.500
180.0000000	5.000

NODE NUMBER 6
DIRECTION OF FORCE 1

0.0000000	2.500
180.0000000	5.000

NODE NUMBER 7
DIRECTION OF FORCE 1

0.0000000	2.500
180.0000000	5.000

NODE NUMBER 8
DIRECTION OF FORCE 1

0.0000000	2.500
180.0000000	5.000

NODE NUMBER 9
DIRECTION OF FORCE 1

0.0000000	1.250
180.0000000	2.500

NODE NUMBER 10
DIRECTION OF FORCE 1

0.0000000	1.250
180.0000000	2.500

SAMPLE OUTPUT FOR PROBLEM # 9 (CONTINUED)


```
NODE NUMBER  11
DIRECTION OF FORCE   1

  0.0000000           2.500

180.0000000           5.000


NODE NUMBER  12
DIRECTION OF FORCE   1

  0.0000000           2.500

180.0000000           5.000

NODE NUMBER  13
DIRECTION OF FORCE   1

  0.0000000           2.500

180.0000000           5.000


NODE NUMBER  14
DIRECTION OF FORCE   1

  0.0000000           2.500

180.0000000           5.000


NODE NUMBER  15
DIRECTION OF FORCE   1

  0.0000000           2.500

180.0000000           5.000


NODE NUMBER  16
DIRECTION OF FORCE   1

  0.0000000           2.500

180.0000000           5.000
```

SAMPLE OUTPUT FOR PROBLEM # 9 (CONTINUED)

FILE: UNYUBMF OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

NODE NUMBER 17
DIRECTION OF FORCE 1

0.0000000	2.500
180.0000000	5.000

NODE NUMBER 18
DIRECTION OF FORCE 1

0.0000000	1.250
180.0000000	2.500

NODE NUMBER 73
DIRECTION OF FORCE 1

0.0000000	-1.250
180.0000000	-2.500

NODE NUMBER 74
DIRECTION OF FORCE 1

0.0000000	-2.500
180.0000000	-5.000

NODE NUMBER 75
DIRECTION OF FORCE 1

0.0000000	-2.500
180.0000000	-5.000

NODE NUMBER 76
DIRECTION OF FORCE 1

0.0000000	-2.500
180.0000000	-5.000

SAMPLE OUTPUT FOR PROBLEM # 9 (CONTINUED)


```
NODE NUMBER   77
DIRECTION OF FORCE   1

   0.0000000          -2.500

 180.0000000          -5.000


NODE NUMBER   78
DIRECTION OF FORCE   1

   0.0000000          -2.500

 180.0000000          -5.000


NODE NUMBER   79
DIRECTION OF FORCE   1

   0.0000000          -2.500

 180.0000000          -5.000


NODE NUMBER   80
DIRECTION OF FORCE   1

   0.0000000          -2.500

 180.0000000          -5.000


NODE NUMBER   81
DIRECTION OF FORCE   1

   0.0000000          -1.250

 180.0000000          -2.500


NODE NUMBER   82
DIRECTION OF FORCE   1

   0.0000000          -1.250

 180.0000000          -2.500
```

SAMPLE OUTPUT FOR PROBLEM # 9 (CONTINUED)

```
FILE: UNYUBMF  OUT     A                    VM/SP CONVERSATIONAL MONITOR SYSTEM                    PAGE 00001

NODE NUMBER   83
DIRECTION OF FORCE    1

   0.0000000              -2.500

 180.0000000              -5.000

NODE NUMBER   84
DIRECTION OF FORCE    1

   0.0000000              -2.500

 180.0000000              -5.000

NODE NUMBER   85
DIRECTION OF FORCE    1

   0.0000000              -2.500

 180.0000000              -5.000

NODE NUMBER   86
DIRECTION OF FORCE    1

   0.0000000              -2.500

 180.0000000              -5.000

NODE NUMBER   87
DIRECTION OF FORCE    1

   0.0000000              -2.500

 180.0000000              -5.000

NODE NUMBER   88
DIRECTION OF FORCE    1

   0.0000000              -2.500

 180.0000000              -5.000
```

SAMPLE OUTPUT FOR PROBLEM # 9 (CONTINUED)

```
FILE: UNYUBMF  OUT      A                VM/SP CONVERSATIONAL MONITOR SYSTEM                PAGE 00001

   NODE NUMBER   89
   DIRECTION OF FORCE    1

      0.0000000              -2.500

    180.0000000              -5.000


   NODE NUMBER   90
   DIRECTION OF FORCE    1

      0.0000000              -1.250

    180.0000000              -2.500

EIGENVALUE NUMBER     1 VALUE =    0.285071E+02



     TIME REQUIRED TO CARRY OUT THE ANALYSIS                          270.403 SEC.
     TIME REQUIRED TO : READ IN DATA                                    0.026 SEC.
                        DO PREPROCESSING                                0.112 SEC.
```

DEMONSTRATION PROBLEM NO. 10

PROBLEM TYPE:

Load stepping and modal analysis of a solid curved panel type structure using plate element subjected to thermo-mechanical loading.

PROBLEM DESCRIPTION:

A curved panel (20 degree segment) of 6" radius, 2" width, and 0.125" thickness with both straight edges clamped and both curved edges free, is subjected to 4 load steps of external pressure (0-2000 psi) and uniform temperature increase (70-1000 F). The curved panel is made of Sic/Ti-15-3-3-3 composite material (Silicon Carbide fiber, Titanium matrix with 15% Vanadium, 3% Aluminum, 3% Chromium, and 3% Tin, and interphase with average properties of fiber and matrix). The composite laminate consists of 4 (0/45/-45/90) plies of equal thickness with 0.4 fiber volume ratio. The ply lay-up is such that the 0 degree ply is at the top and the 90 degree at the bottom of the curved panel. The ply lay-up is same as that used for problem # 4 shown on page 26. The material properties at the reference temperature of 70 F are listed in Table II. The exponents for material property variations according to the nonlinear multi-factor interaction model (Ref. 1) are listed in Table III. Results are to be generated both for the displacement and stress responses and for natural frequencies at each load step accounting for the nonlinear material behavior. The geometry, boundary conditions, loading, and ply lay-up are shown in the figure on next page.

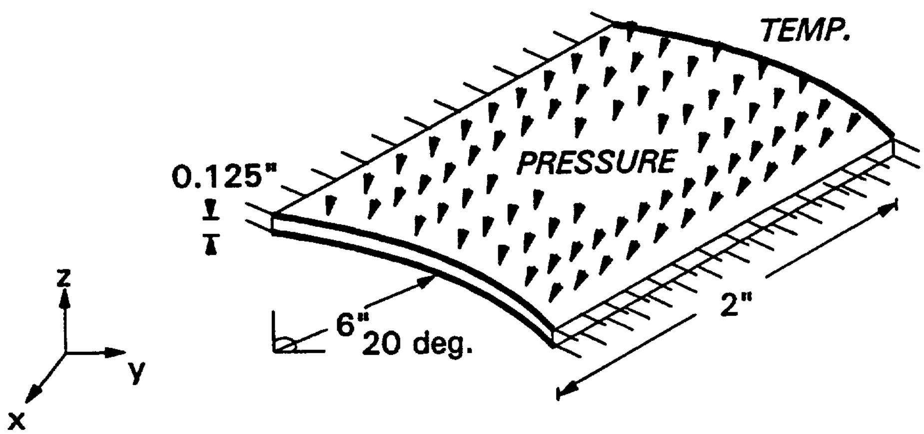
MODELING HINTS:

The finite element mesh consists of 8 elements in the x-direction and 8 along the curved edge (IU = 9 and JU = 9 on card group # 3). The mesh is same as that used for problem # 4 shown on page 27. The material property data file, "DATA BANK" is included in Appendix 1.

PROBLEM # 10

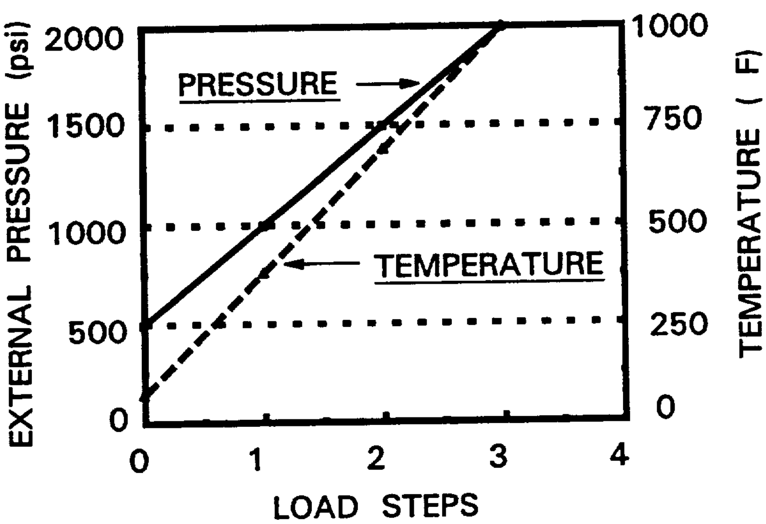
FIXED-FREE CURVED PANEL UNDER BENDING & UNIFORM TEMPERATURE LOADINGS FOR (Si C/Ti-15-3-3-3, 0/±45/90); 0.4 FIBER VOLUME RATIO

GEOMETRY, BOUNDARY CONDITIONS, AND LOADING



(REF. TEMP. = 70 F)

LOAD STEPPING HISTORY



INPUT DECK SETUP FOR PROBLEM # 10

```
FILE: SNNUMCF   DEMO    A1                    VM/SP CONVERSATIONAL MONITOR

TITLE=PROBLEMS #10,MODAL & LOAD STEPPING(BASE CASE) ANALYSIS FOR
TITLE=CURVED PANEL(20 deg. SHELL ROOF),FIXED STRAIGHT EDGES,FREE CURVE
TITLE=EDGES,EXTERNAL PRESSURE(2000 PSI),UNIFORM TEMP. of 1000 F(REFERE
TITLE=TEMP. = 70 F),R=6",W=2",T=.125",4(0/45/-45/90)PLIES,FVR=.4,
TITLE=8X8 MESH, NO FABRICATION EFFECTS, NO FIBER DEGRADATION EFFECTS.
SPLATE
PLATE
PRESSURE
TEMPERATURE
MODES
PLYORDER
UNSYMMETRICAL
ENDOPTION
    4
    2
    4   9   9   4
       0.       2.
    2
    2
    4   1   1   1   5  10
      1.0
    3  30  40
    0
    0
   11
    5   5
    8
       0. -1.0420  5.9100  0.1250
       0. -0.5230  5.9775  0.1250
       0.      0.  6.0000  0.1250
       0.  0.5230  5.9775  0.1250
       0.  1.0420  5.9100  0.1250
    0
       2. -1.0420  5.9100  0.1250
       2. -0.5230  5.9775  0.1250
       2.      0.  6.0000  0.1250
       2.  0.5230  5.9775  0.1250
       2.  1.0420  5.9100  0.1250
       0.0      100.0       0.0     100.0       0.0     100.0
SICA TI15    0.03125       0.0      0.40       0.0
       0.0      100.0       0.0     100.0       0.0     100.0
SICA TI15    0.03125       0.0      0.40      45.0
       0.0      100.0       0.0     100.0       0.0     100.0
```

INPUT DECK SETUP FOR PROBLEM # 10 (CONTINUED)

```
FILE: SNNUMCF   DEMO    A1                    VM/SP CONVERSATIONAL MONITOR

SICA TI15     0.03125      0.0      0.40     -45.0
     0.0       100.0       0.0     100.0       0.0      100.0
SICA TI15     0.03125      0.0      0.40      90.0
   4   3
   1   2
      0.        60.       120.      180.
     70.        70.       00.0      500.
     70.        70.       00.0      500.
     70.        70.       00.0      500.
     70.        70.       00.0      500.
     70.        70.       00.0      500.
     70.        70.       00.0      500.
     70.        70.       00.0      500.
     70.        70.       00.0      500.
     70.        70.       00.0      500.
     70.        70.       00.0      500.
    380.       380.      000.0     1000.
    380.       380.      000.0     1000.
    380.       380.      000.0     1000.
    380.       380.      000.0     1000.
    380.       380.      000.0     1000.
    380.       380.      000.0     1000.
    380.       380.      000.0     1000.
    380.       380.      000.0     1000.
    380.       380.      000.0     1000.
    380.       380.      000.0     1000.
    690.       690.       00.0     1500.
    690.       690.       00.0     1500.
    690.       690.       00.0     1500.
    690.       690.       00.0     1500.
    690.       690.       00.0     1500.
    690.       690.       00.0     1500.
    690.       690.       00.0     1500.
    690.       690.       00.0     1500.
    690.       690.       00.0     1500.
    690.       690.       00.0     1500.
   1000.      1000.      000.0     2000.
   1000.      1000.      000.0     2000.
   1000.      1000.      000.0     2000.
   1000.      1000.      000.0     2000.
   1000.      1000.      000.0     2000.
   1000.      1000.      000.0     2000.
   1000.      1000.      000.0     2000.
   1000.      1000.      000.0     2000.
```

INPUT DECK SETUP FOR PROBLEM # 10 (CONTINUED)

```
FILE: SNNUMCF   DEMO    A1                  VM/SP CONVERSATIONAL MONITOR

     1000.      1000.      000.0      2000.
     1000.      1000.      000.0      2000.
   1  73    9   2
   1  73    9   3
   1  73    9   4
   1  73    9   5
   1  73    9   6
   9  81    9   2
   9  81    9   3
   9  81    9   4
   9  81    9   5
   9  81    9   6
  37  45    8   1
   1  81
   1  81
   5   5
   1   1
       0.0       60.0      120.0      180.0
       0.0       60.0      120.0      180.0
```

SAMPLE OUTPUT FOR PROBLEM # 10

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 0 DEG. AT TOP)

FILE: SNNUMCF OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

DISPLACEMENTS AFTER THE INITIAL LOAD AT SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
5	-0.373E-03	0.100E-05	-0.319E-02	0.372E-04	-0.745E-03	-0.411E-04

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 5

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	0.661E+03	0.133E+04	0.000E+00	-0.134E+03	-0.268E+02	0.389E+02
2	-0.500E+04	-0.343E+04	0.000E+00	0.382E+04	-0.183E+02	-0.996E+02
3	-0.105E+05	-0.808E+04	0.000E+00	-0.695E+04	-0.996E+02	0.183E+02
4	0.147E+04	-0.213E+05	0.000E+00	0.302E+03	-0.389E+02	-0.268E+02

NODE # 5

MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 0.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	0.1211E+05	SIGM11A	-0.5614E+04	SIGD11B	0.5881E+04	SIGL11	0.1474E+04
3	SIGF22	-0.2470E+05	SIGM22A	-0.1470E+05	SIGD22B	-0.2372E+05	SIGL22	-0.2129E
4	SIGF12	0.1895E+04	SIGM22B	-0.2372E+05	SIGD22C	-0.2470E+05	SIGL33	0.0000E+
5	SIGF23	-0.1816E+03	SIGM22C	-0.2470E+05	SIGD12B	0.9692E+03	SIGL12	0.3017E+03
6	SIGF13	-0.2445E+03	SIGM12A	0.1824E+03	SIGD12C	0.1132E+04	SIGL23	-0.3891E+02
7	SIGF33	0.3881E+03	SIGM12B	0.3174E+03	SIGD23B	-0.9281E+02	SIGL13	-0.2682E+02
8			SIGM12C	0.3708E+03	SIGD23C	-0.1085E+03		
9			SIGM23A	-0.1746E+02	SIGD13B	-0.1250E+03		
10			SIGM23B	-0.3039E+02	SIGD13C	-0.1462E+03		
11			SIGM23C	-0.3554E+02	SIGD33B	-0.2184E+04		
12			SIGM13A	-0.2352E+02	SIGD33C	0.3881E+03		
13			SIGM13B	-0.4092E+02	SIGD11C	0.5865E+04		
14			SIGM13C	-0.4786E+02				
15			SIGM33A	-0.1441E+04				
16			SIGM33B	-0.2184E+04				
17			SIGM33C	0.3881E+03				
18			SIGM11B	-0.5614E+04				
19			SIGM11C	-0.5614E+04				

TIME 60.0000000

SAMPLE OUTPUT FOR PROBLEM # 10 (CONTINUED)

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
5	-0.169E-02	-0.137E-05	-0.356E-02	0.766E-04	0.371E-03	-0.463E-04

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 0 DEG. AT TOP)

FILE: SNNUMCF OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 5

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.257E+05	0.245E+04	0.000E+00	-0.148E+03	-0.626E+02	0.116E+02
2	-0.156E+05	-0.121E+05	0.000E+00	0.126E+05	0.773E+02	-0.112E+03
3	-0.226E+05	-0.181E+05	0.000E+00	-0.156E+05	-0.112E+03	-0.773E+02
4	0.411E+04	-0.401E+05	0.000E+00	0.438E+03	-0.116E+02	-0.626E+02

NODE # 5

MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 60.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	0.3406E+05	SIGM11A	-0.1585E+05	SIGD11B	0.6038E+04	SIGL11	0.4114E+04
3	SIGF22	-0.4326E+05	SIGM22A	-0.3321E+05	SIGD22B	-0.2502E+05	SIGL22	-0.4014E+05
4	SIGF12	0.2832E+04	SIGM22B	-0.4872E+05	SIGD22C	-0.1856E+05	SIGL33	0.0000E+00
5	SIGF23	-0.4642E+03	SIGM22C	-0.4326E+05	SIGD12B	0.4690E+03	SIGL12	0.4378E+03
6	SIGF13	-0.5669E+02	SIGM12A	0.2630E+03	SIGD12C	0.5464E+03	SIGL23	-0.1157E+02
7	SIGF33	0.4454E+04	SIGM12B	0.4612E+03	SIGD23B	-0.1416E+03	SIGL13	-0.6258E+02
8			SIGM12C	0.5389E+03	SIGD23C	-0.1653E+03		
9			SIGM23A	-0.4201E+02	SIGD13B	0.9393E+02		
10			SIGM23B	-0.7398E+02	SIGD13C	0.1097E+03		
11			SIGM23C	-0.8638E+02	SIGD33B	-0.7508E+04		
12			SIGM13A	-0.7231E+01	SIGD33C	0.4066E+04		
13			SIGM13B	-0.1197E+02	SIGD11C	0.6115E+04		
14			SIGM13C	-0.1412E+02				
15			SIGM33A	-0.9231E+04				
16			SIGM33B	-0.9689E+04				
17			SIGM33C	0.4454E+04				
18			SIGM11B	-0.1585E+05				
19			SIGM11C	-0.1585E+05				

TIME 120.0000000

SAMPLE OUTPUT FOR PROBLEM # 10 (CONTINUED)

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
5	-0.310E-02	-0.508E-05	-0.421E-02	0.130E-03	0.172E-02	-0.564E-04

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 0 DEG. AT TOP)

FILE: SNNUMCF OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 5

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.525E+05	0.382E+04	0.000E+00	-0.167E+03	-0.102E+03	-0.168E+02
2	-0.262E+05	-0.205E+05	0.000E+00	0.210E+05	0.180E+03	-0.129E+03
3	-0.353E+05	-0.281E+05	0.000E+00	-0.240E+05	-0.129E+03	-0.180E+03
4	0.719E+04	-0.589E+05	0.000E+00	0.656E+03	0.168E+02	-0.102E+03

NODE # 5

MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 120.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	0.6137E+05	SIGM11A	-0.2896E+05	SIGD11B	0.9076E+04	SIGL11	0.7187E+'
3	SIGF22	-0.6194E+05	SIGM22A	-0.5094E+05	SIGD22B	-0.2312E+05	SIGL22	-0.5889E+
4	SIGF12	0.4498E+04	SIGM22B	-0.7182E+05	SIGD22C	-0.1864E+05	SIGL33	0.0000E+00
5	SIGF23	-0.8422E+03	SIGM22C	-0.6194E+05	SIGD12B	0.8239E+03	SIGL12	0.6560E+03
6	SIGF13	0.1605E+03	SIGM12A	0.3905E+03	SIGD12C	0.9558E+03	SIGL23	0.1683E+02
7	SIGF33	0.8421E+04	SIGM12B	0.6943E+03	SIGD23B	-0.1860E+03	SIGL13	-0.1020E+03
8			SIGM12C	0.8096E+03	SIGD23C	-0.2164E+03		
9			SIGM23A	-0.7888E+02	SIGD13B	0.1068E+03		
10			SIGM23B	-0.1268E+03	SIGD13C	0.1242E+03		
11			SIGM23C	-0.1478E+03	SIGD33B	-0.6812E+04		
12			SIGM13A	0.9351E+01	SIGD33C	0.3971E+04		
13			SIGM13B	0.1831E+02	SIGD11C	0.9134E+04		
14			SIGM13C	0.2116E+02				
15			SIGM33A	-0.1699E+05				
16			SIGM33B	-0.1650E+05				
17			SIGM33C	0.8421E+04				
18			SIGM11B	-0.2896E+05				
19			SIGM11C	-0.2896E+05				

TIME 180.0000000

SAMPLE OUTPUT FOR PROBLEM # 10 (CONTINUED)

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
5	-0.444E-02	-0.133E-04	-0.580E-02	0.136E-03	0.451E-02	-0.833E-04

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 0 DEG. AT TOP)

FILE: SNNUMCF OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 5

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.697E+05	0.476E+04	0.000E+00	-0.468E+03	-0.731E+02	-0.684E+02
2	-0.324E+05	-0.290E+05	0.000E+00	0.279E+05	0.214E+03	-0.717E+01
3	-0.454E+05	-0.394E+05	0.000E+00	-0.311E+05	-0.717E+01	-0.214E+03
4	0.111E+05	-0.770E+05	0.000E+00	0.898E+03	0.684E+02	-0.731E+02

NODE # 5

MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 180.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	0.9990E+05	SIGM11A	-0.4811E+05	SIGD11B	0.3757E+04	SIGL11	0.1112E+05
3	SIGF22	-0.7960E+05	SIGM22A	-0.6814E+05	SIGD22B	-0.3493E-04	SIGL22	-0.7704E+05
4	SIGF12	0.6654E+04	SIGM22B	0.0000E+00	SIGD22C	-0.1770E+05	SIGL33	0.0000E+00
5	SIGF23	-0.4820E+03	SIGM22C	-0.7960E+05	SIGD12B	0.1044E+04	SIGL12	0.8984E+03
6	SIGF13	0.6193E+03	SIGM12A	0.5295E+03	SIGD12C	0.1202E+04	SIGL23	0.6836E+02
7	SIGF33	0.1251E+05	SIGM12B	0.9568E+03	SIGD23B	0.1734E+03	SIGL13	-0.7309E+02
8			SIGM12C	0.1112E+04	SIGD23C	0.2003E+03		
9			SIGM23A	-0.4781E+02	SIGD13B	0.2208E+03		
10			SIGM23B	-0.8322E+02	SIGD13C	0.2550E+03		
11			SIGM23C	-0.9743E+02	SIGD33B	-0.4059E+04		
12			SIGM13A	0.3875E+02	SIGD33C	0.4093E+04		
13			SIGM13B	0.7404E+02	SIGD11C	0.3485E+04		
14			SIGM13C	0.8559E+02				
15			SIGM33A	-0.2514E+05				
16			SIGM33B	-0.2056E+05				
17			SIGM33C	0.1251E+05				
18			SIGM11B	-0.4811E+05				
19			SIGM11C	-0.4811E+05				

TIME REQUIRED TO CARRY OUT THE ANALYSIS 374.321 SEC.

TIME REQUIRED TO : READ IN DATA 0.021 SEC.
DO PREPROCESSING 0.128 SEC.

DEMONSTRATION PROBLEM NO. 11

PROBLEM TYPE:

Load stepping and modal analysis of a hollow sandwich type built-up structure using plate element subjected to thermo-mechanical loading.

PROBLEM DESCRIPTION:

A hollow built-up structure of 0.5" length, 0.2" width, 0.075" total thickness, 0.02" thickness of top plate, 0.01" thickness of bottom plate, and 3 spars in the x-z plane equally spaced in the y-direction with 0.02" thickness the z-direction, with bottom surface fixed in vertical direction, is subjected to 4 load steps of internal pressure (0-2000 psi) and uniform temperature increase (70-1000 F). The built-up structure is made of Sic/Ti-15-3-3-3 composite material (Silicon Carbide fiber, Titanium matrix with 15% Vanadium, 3% Aluminum, 3% Chromium, and 3% Tin, and interphase with average properties of fiber and matrix). The composite laminate consists of 4 (90/0/0/90) plies of equal thickness for the top plate, 2 (90/90) plies of equal thickness for the bottom plate, and 4 (0/0/0/0) plies of equal thickness for the spars, all with 0.4 fiber volume ratio. The ply lay-up is symmetric for all parts of the structure. The ply lay-up is same as that used for problem # 5 shown on pages 33-34. The material properties at the reference temperature of 70 F are listed in Table II. The exponents for material property variations according to the nonlinear multi-factor interaction model (Ref. 1) are listed in Table III. Results are to be generated both for the displacement and stress responses and for natural frequencies at each load step accounting for the nonlinear material behavior. The geometry, boundary conditions, loading, and ply lay-up are shown in the figure on next page.

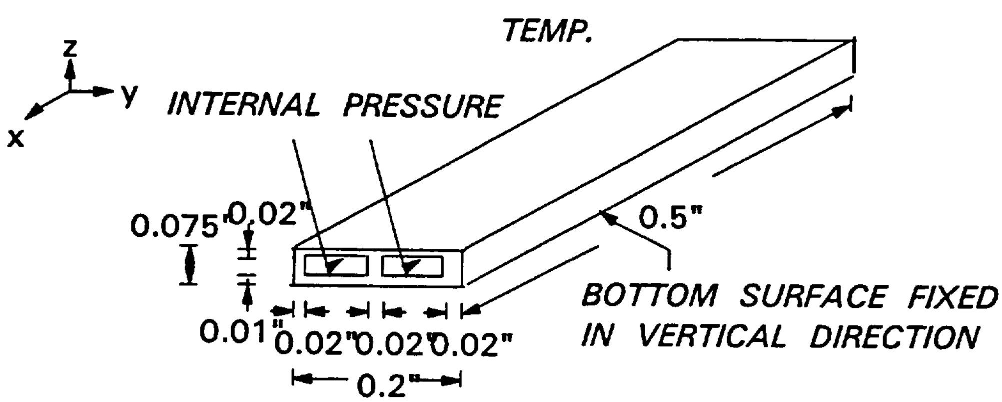
MODELING HINTS:

The finite element mesh consists of 4 elements in the x-direction and 8 in the y-direction for both the top and bottom plates and 4 elements in the x-direction and 1 element in the z-direction for all each of the 3 spars. The mesh is same as that used for problem # 5 shown on pages 35-36. The material property data file, "DATA BANK" is included in Appendix 1.

PROBLEM # 11

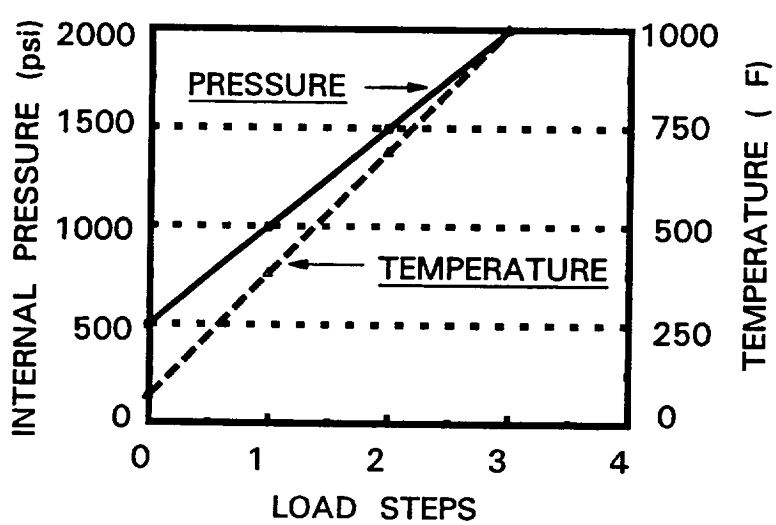
BOTTOM SUPPORTED BUILT-UP STRUCTURE UNDER BENDING & UNIFORM TEMP. LOADINGS
FOR (Si C/Ti-15-3-3-3, TOP:[90,0] $_s$, BOTTOM:[90] $_s$, SPARS:4[0] $_s$); 0.4 FIBER VOLUME RATIO

GEOMETRY, BOUNDARY CONDITIONS, AND LOADING



(REF. TEMP. = 70 F)

LOAD STEPPING HISTORY



INPUT DECK SETUP FOR PROBLEM # 11

FILE: UNNUMCF DEMO A1 VM/SP CONVERSATIONAL MONITOR

```
TITLE=PANEL,BOTTOM FIXED IN Z-DIRECTION+,INSIDE AT1000 F & 500-2000 P
TITLE=OUTSIDE AT 1000 F & 0 PSI IN 3 MINUTES,4X8(TOP)-8(BOT)-12(SPAR)
TITLE=3 SPARS-.02" THICK-4(1,-1,-1,1)PLY TYPE,TOP-.02"-4(2,1,1,2)PLIE
TITLE=BOTTOM-.01"-2(2,2)PLIES,L=.5",W=.2",H=.075"
TITLE=NO FABRICATION,NO FIBER DEGRADATION,2 MODES
HPLATE
PLATE
PROFILE
MODES
PLYORDER
TEMPERATURE
PRESSURE
PANEL
ENDOPTION
   2
   2   2   3   7
   2
   3   3
   4   1   1   1   5  10
    1.0
   2  30  40
   0
   0
   8
   1   1   1
   2  0.00
    0.000        .02      0.000       .02      0.000       .02
   2  0.25
    0.000        .02      0.000       .02      0.000       .02
      0.50
    0.000        .02      0.000       .02      0.000       .02
   3   3   3
   3   3   3
    0.0000   -0.1000   0.0400   0.0200
    0.0000    0.0000   0.0400   0.0200
    0.0000    0.1000   0.0400   0.0200
    0.2500   -0.1000   0.0400   0.0200
    0.2500    0.0000   0.0400   0.0200
    0.2500    0.1000   0.0400   0.0200
    0.5000   -0.1000   0.0400   0.0200
    0.5000    0.0000   0.0400   0.0200
    0.5000    0.1000   0.0400   0.0200
    0.0000   -0.1000  -0.0350   0.0100
    0.0000    0.0000  -0.0350   0.0100
    0.0000    0.1000  -0.0350   0.0100
```

INPUT DECK SETUP FOR PROBLEM # 11(CONTINUED)

FILE: UNNUMCF DEMO A1 VM/SP CONVERSATIONAL MONITOR

```
     0.2500  -0.1000  -0.0350   0.0100
     0.2500   0.0000  -0.0350   0.0100
     0.2500   0.1000  -0.0350   0.0100
     0.5000  -0.1000  -0.0350   0.0100
     0.5000   0.0000  -0.0350   0.0100
     0.5000   0.1000  -0.0350   0.0100
        0.0      0.0      0.0    100.0       0.0      100.0
 SICA TI15    .00500      0.0     0.40       0.0
        0.0      0.0      0.0    100.0       0.0      100.0
 SICA TI15    .00500      0.0     0.40      90.0
    2   1
         0.      60.     120.     180.
        70.      70.       0.     500.
        70.      70.       0.     500.
        70.      70.       0.     500.
        70.      70.       0.     500.
        70.      70.       0.     500.
        70.      70.       0.     500.
        70.      70.       0.     500.
        70.      70.       0.     500.
        70.      70.       0.     500.
        70.      70.     500.      00.
        70.      70.     500.      00.
        70.      70.     500.      00.
        70.      70.     500.      00.
        70.      70.     500.      00.
        70.      70.     500.      00.
        70.      70.     500.      00.
        70.      70.     500.      00.
        70.      70.     500.      00.
       380.     380.       0.    1000.
       380.     380.       0.    1000.
       380.     380.       0.    1000.
       380.     380.       0.    1000.
       380.     380.       0.    1000.
       380.     380.       0.    1000.
       380.     380.       0.    1000.
       380.     380.       0.    1000.
       380.     380.       0.    1000.
       380.     380.    1000.     000.
       380.     380.    1000.     000.
       380.     380.    1000.     000.
       380.     380.    1000.     000.
       380.     380.    1000.     000.
       380.     380.    1000.     000.
```

INPUT DECK SETUP FOR PROBLEM # 11(CONTINUED)

```
FILE: UNNUMCF    DEMO      A1                  VM/SP CONVERSATIONAL MONITOR
         380.       380.     1000.        000.
         380.       380.     1000.        000.
         380.       380.     1000.        000.
         690.       690.        0.       1500.
         690.       690.        0.       1500.
         690.       690.        0.       1500.
         690.       690.        0.       1500.
         690.       690.        0.       1500.
         690.       690.        0.       1500.
         690.       690.        0.       1500.
         690.       690.        0.       1500.
         690.       690.        0.       1500.
         690.       690.     1500.         00.
         690.       690.     1500.         00.
         690.       690.     1500.         00.
         690.       690.     1500.         00.
         690.       690.     1500.         00.
         690.       690.     1500.         00.
         690.       690.     1500.         00.
         690.       690.     1500.         00.
         690.       690.     1500.         00.
        1000.      1000.        0.       2000.
        1000.      1000.        0.       2000.
        1000.      1000.        0.       2000.
        1000.      1000.        0.       2000.
        1000.      1000.        0.       2000.
        1000.      1000.        0.       2000.
        1000.      1000.        0.       2000.
        1000.      1000.        0.       2000.
        1000.      1000.        0.       2000.
        1000.      1000.     2000.        000.
        1000.      1000.     2000.        000.
        1000.      1000.     2000.        000.
        1000.      1000.     2000.        000.
        1000.      1000.     2000.        000.
        1000.      1000.     2000.        000.
        1000.      1000.     2000.        000.
        1000.      1000.     2000.        000.
        1000.      1000.     2000.        000.
   37   46   9   1
   45   54   9   1
   41   50   9   2
   10   18   1   3
   28   36   1   3
   46   54   1   3
```

SAMPLE OUTPUT FOR PROBLEM # 11

```
64  72   1   3
82  90   1   3
 1 120
 1 120
 3   3  12  12
 4   4
      0.       60.      120.      180.
      0.       60.      120.      180.
```

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 90 DEG. AT TOP)

FILE: UNNUMCF OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

DISPLACEMENTS AFTER THE INITIAL LOAD AT SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
12	-0.524E-04	-0.981E-05	0.110E-30	-0.189E-04	0.956E-05	-0.141E-05

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 3

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.193E+04	-0.596E+03	0.000E+00	0.289E+02	0.656E+02	-0.525E+01
2	0.379E+02	-0.572E+03	0.000E+00	-0.176E+02	0.112E+02	0.141E+03
3	0.143E+03	0.449E+03	0.000E+00	-0.638E+01	0.112E+02	0.141E+03
4	0.303E+04	-0.247E+02	0.000E+00	-0.488E+01	0.656E+02	-0.525E+01

NODE # 3

MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 0.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	0.7538E+04	SIGM11A	0.2880E+02	SIGD11B	0.2903E+04	SIGL11	0.3032E+04
3	SIGF22	0.1035E+04	SIGM22A	-0.1853E+04	SIGD22B	-0.1778E+04	SIGL22	-0.2473E+02
4	SIGF12	-0.3063E+02	SIGM22B	-0.1787E+04	SIGD22C	0.1035E+04	SIGL33	0.0000E+00
5	SIGF23	-0.3351E+02	SIGM22C	0.1035E+04	SIGD12B	-0.1567E+02	SIGL12	-0.4875E+01
6	SIGF13	0.4123E+03	SIGM12A	-0.2946E+01	SIGD12C	-0.1831E+02	SIGL23	0.6562E+02
7	SIGF33	0.4890E+03	SIGM12B	-0.5131E+01	SIGD23B	-0.1713E+02	SIGL13	-0.5250E+01
8			SIGM12C	-0.5996E+01	SIGD23C	-0.2004E+02		
9			SIGM23A	-0.3224E+01	SIGD13B	0.2108E+03		
10			SIGM23B	-0.5610E+01	SIGD13C	0.2465E+03		
11			SIGM23C	-0.6561E+01	SIGD33B	-0.2255E+04		
12			SIGM13A	0.3966E+02	SIGD33C	0.4890E+03		
13			SIGM13B	0.6901E+02	SIGD11C	0.2904E+04		
14			SIGM13C	0.8070E+02				
15			SIGM33A	-0.2134E+04				
16			SIGM33B	-0.2255E+04				

SAMPLE OUTPUT FOR PROBLEM # 11(CONTINUED)

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 90 DEG. AT TOP)

FILE: UNNUMCF OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM

17	SIGM33C	0.4890E+03
18	SIGM11B	0.2880E+02
19	SIGM11C	0.2880E+02

TIME 60.0000000

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
12	-0.305E-03	-0.582E-04	0.203E-30	-0.354E-04	0.234E-04	0.373E-05

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 3

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.293E+04	-0.210E+04	0.000E+00	0.285E+02	0.135E+03	-0.952E+01
2	0.884E+03	-0.195E+04	0.000E+00	-0.750E+01	0.204E+02	0.288E+03
3	0.105E+04	0.633E+02	0.000E+00	0.135E+02	-0.204E+02	0.288E+03
4	0.726E+04	-0.102E+04	0.000E+00	-0.345E+02	0.135E+03	-0.952E+01

NODE # 3

MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 60.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	0.2385E+05	SIGM11A	-0.3806E+04	SIGD11B	0.2615E+04	SIGL11	0.7255E+04
3	SIGF22	0.4524E+04	SIGM22A	-0.1059E+05	SIGD22B	-0.8047E+04	SIGL22	-0.1019E+04
4	SIGF12	-0.2335E+03	SIGM22B	-0.9850E+04	SIGD22C	0.3484E+04	SIGL33	0.0000E+00
5	SIGF23	-0.6357E+02	SIGM22C	0.4524E+04	SIGD12B	-0.1021E+03	SIGL12	-0.3450E+02
6	SIGF13	0.8840E+03	SIGM12A	-0.2058E+02	SIGD12C	-0.1188E+03	SIGL23	0.1345E+03
7	SIGF33	0.4602E+04	SIGM12B	-0.3658E+02	SIGD23B	-0.1508E+02	SIGL13	-0.9516E+01
8			SIGM12C	-0.4259E+02	SIGD23C	-0.1761E+02		
9			SIGM23A	-0.5832E+01	SIGD13B	0.2368E+03		
10			SIGM23B	-0.1025E+02	SIGD13C	0.2765E+03		
11			SIGM23C	-0.1198E+02	SIGD33B	-0.7528E+04		
12			SIGM13A	0.8070E+02	SIGD33C	0.4113E+04		
13			SIGM13B	0.1419E+03	SIGD11C	0.2618E+04		
14			SIGM13C	0.1658E+03				
15			SIGM33A	-0.1056E+05				
16			SIGM33B	-0.9778E+04				
17			SIGM33C	0.4602E+04				
18			SIGM11B	-0.3806E+04				
19			SIGM11C	-0.3806E+04				

SAMPLE OUTPUT FOR PROBLEM # 11(CONTINUED)

FILE: UNNUNCF OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

TIME 120.0000000

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
12	-0.577E-03	-0.110E-03	0.288E-30	-0.520E-04	0.362E-04	0.126E-04

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 90 DEG. AT TOP)

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 3

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.382E+04	-0.367E+04	0.000E+00	0.225E+02	0.210E+03	-0.131E+02
2	0.181E+04	-0.340E+04	0.000E+00	0.485E+01	0.281E+02	0.450E+03
3	0.201E+04	-0.470E+03	0.000E+00	0.322E+02	0.281E+02	0.450E+03
4	0.116E+05	-0.215E+04	0.000E+00	-0.594E+02	0.210E+03	-0.131E+02

NODE # 3

MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 120.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	0.4154E+05	SIGM11A	-0.8378E+04	SIGD11B	0.3593E+04	SIGL11	0.1161E+05
3	SIGF22	0.7798E+04	SIGM22A	-0.1941E+05	SIGD22B	-0.7343E+04	SIGL22	-0.2150E+04
4	SIGF12	-0.4248E+03	SIGM22B	-0.1721E+05	SIGD22C	0.3278E+04	SIGL33	0.0000E+00
5	SIGF23	-0.9241E+02	SIGM22C	0.7798E+04	SIGD12B	-0.9420E+02	SIGL12	-0.5945E+02
6	SIGF13	0.1461E+04	SIGM12A	-0.3517E+02	SIGD12C	-0.1092E+03	SIGL23	0.2100E+03
7	SIGF33	0.8689E+04	SIGM12B	-0.6333E+02	SIGD23B	-0.1416E+02	SIGL13	-0.1312E+02
8			SIGM12C	-0.7358E+02	SIGD23C	-0.1648E+02		
9			SIGM23A	-0.8029E+01	SIGD13B	0.2840E+03		
10			SIGM23B	-0.1432E+02	SIGD13C	0.3303E+03		
11			SIGM23C	-0.1668E+02	SIGD33B	-0.6678E+04		
12			SIGM13A	0.1248E+03	SIGD33C	0.4089E+04		
13			SIGM13B	0.2225E+03	SIGD11C	0.3595E+04		
14			SIGM13C	0.2597E+03				
15			SIGM33A	-0.1903E+05				
16			SIGM33B	-0.1646E+05				
17			SIGM33C	0.8689E+04				
18			SIGM11B	-0.8378E+04				
19			SIGM11C	-0.8378E+04				

TIME 180.0000000

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
12	-0.877E-03	-0.167E-03	0.368E-30	-0.679E-04	0.484E-04	0.232E-04

SAMPLE OUTPUT FOR PROBLEM # 11(CONTINUED)

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 90 DEG. AT TOP)

FILE: UNNUMCF OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 3

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.453E+04	-0.535E+04	0.000E+00	0.116E+02	0.285E+03	-0.162E+02
2	0.286E+04	-0.496E+04	0.000E+00	0.225E+02	0.348E+02	0.612E+03
3	0.307E+04	-0.121E+04	0.000E+00	0.565E+02	0.348E+02	0.612E+03
4	0.162E+05	-0.348E+04	0.000E+00	-0.906E+02	0.285E+03	-0.162E+02

NODE # 3

MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 180.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	0.6127E+05	SIGM11A	-0.1394E+05	SIGD11B	0.5177E+04	SIGL11	0.1618E+05
3	SIGF22	0.1078E+05	SIGM22A	-0.2830E+05	SIGD22B	-0.6517E+04	SIGL22	-0.3478E+04
4	SIGF12	-0.7018E+03	SIGM22B	-0.2374E+05	SIGD22C	0.2977E+04	SIGL33	0.0000E+00
5	SIGF23	-0.1218E+03	SIGM22C	0.1078E+05	SIGD12B	-0.1340E+03	SIGL12	-0.9057E+02
6	SIGF13	0.2131E+04	SIGM12A	-0.5295E+02	SIGD12C	-0.1541E+03	SIGL23	0.2855E+03
7	SIGF33	0.1275E+05	SIGM12B	-0.9712E+02	SIGD23B	-0.1415E+02	SIGL13	-0.1624E+02
8			SIGM12C	-0.1125E+03	SIGD23C	-0.1634E+02		
9			SIGM23A	-0.9913E+01	SIGD13B	0.3237E+03		
10			SIGM23B	-0.1787E+02	SIGD13C	0.3738E+03		
11			SIGM23C	-0.2083E+02	SIGD33B	-0.5629E+04		
12			SIGM13A	0.1681E+03	SIGD33C	0.4060E+04		
13			SIGM13B	0.3046E+03	SIGD11C	0.5180E+04		
14			SIGM13C	0.3543E+03				
15			SIGM33A	-0.2742E+05				
16			SIGM33B	-0.2213E+05				
17			SIGM33C	0.1275E+05				
18			SIGM11B	-0.1394E+05				
19			SIGM11C	-0.1394E+05				

TIME REQUIRED TO CARRY OUT THE ANALYSIS 470.028 SEC.

TIME REQUIRED TO : READ IN DATA 0.032 SEC.
DO PREPROCESSING 0.145 SEC.

DEMONSTRATION PROBLEM NO. 12

PROBLEM TYPE:

Load stepping analysis of a solid curved panel type structure using plate element subjected to thermo-mechanical loading including fabrication load history.

PROBLEM DESCRIPTION:

A curved panel (20 degree segment) of 6" radius, 2" width, and 0.125" thickness with both straight edges clamped and both curved edges free, is subjected to 4 load steps of external pressure (0-2000 psi) and uniform temperature increase (70-1000 F). The curved panel is made of Sic/Ti-15-3-3-3 composite material (Silicon Carbide fiber, Titanium matrix with 15% Vanadium, 3% Aluminum, 3% Chromium, and 3% Tin, and interphase with average properties of fiber and matrix). The composite laminate consists of 4 (0/45/-45/90) plies of equal thickness with 0.4 fiber volume ratio. The ply lay-up is such that the 0 degree ply is at the top and the 90 degree at the bottom of the curved panel. The ply lay-up is same as that used for problem # 4 shown on page 26. The material properties at the reference temperature of 70 F are listed in Table II. The exponents for material property variations according to the nonlinear multi-factor interaction model (Ref. 1) are listed in Table III. Results are to be generated for the displacement and stress responses at each load step including the fabrication load history, accounting for the nonlinear material behavior. The geometry, boundary conditions, loading, and ply lay-up are shown in the figure on next page.

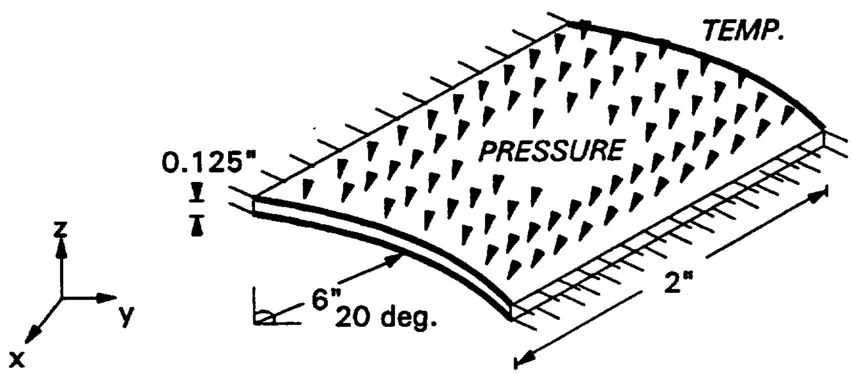
MODELING HINTS:

The finite element mesh consists of 8 elements in the x-direction and 8 along the curved edge (IU = 9 and JU = 9 on card group # 3). The mesh is same as that used for problem # 4 shown on page 27. The material property data file, "DATA BANK" is included in Appendix 1.

PROBLEM # 12

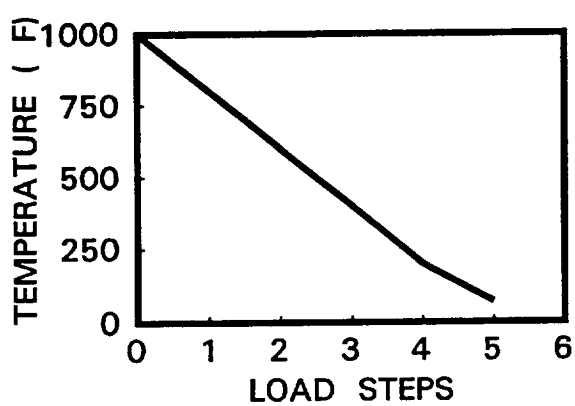
FIXED-FREE CURVED PANEL UNDER BENDING & UNIFORM TEMPERATURE LOADINGS, FOLLOWED BY FABRICATION THERMAL COOLING LOAD FOR (Si C/Ti-15-3-3-3, 0/±45/90); 0.4 FIBER VOLUME RATIO

GEOMETRY, BOUNDARY CONDITIONS, AND LOADING

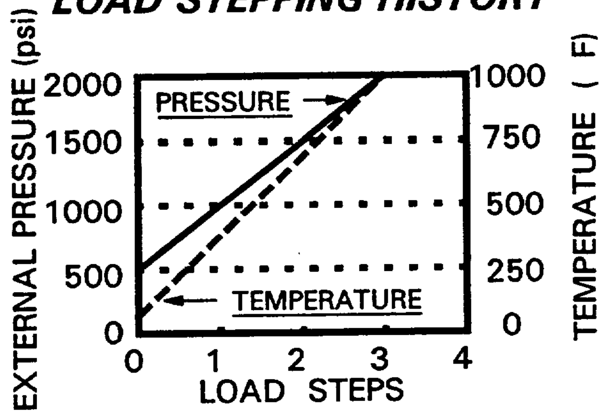


(REF. TEMP. = 70 F)

FABRICATION THERMAL COOLING LOAD HISTORY



LOAD STEPPING HISTORY



INPUT DECK SETUP FOR PROBLEM # 12-A (Fabrication Load)

```
FILE: SYNUMCF   DEMO    A1                    VM/SP CONVERSATIONAL MONITOR

 TITLE=PROBLEM #12A,MODAL & LOAD STEPPING(SENSITIVITY)ANALYSIS FOR CUR
 TITLE=PANEL(20 deg. SHELL ROOF),FIXED STRAIGHT EDGES,FREE CURVED EDGE
 TITLE=EXTERNAL PRESSURE(2000 PSI),UNIFORM TEMP. of 1000 F(REF. TEMP.
 TITLE=F),R=6",W=2",T=.125",4(0/45/-45/90)PLIES,FVR=.4,8X8 MESH,
 TITLE=FABRICATION EFFECTS INCLUDED, NO FIBER DEGRADATION EFFECTS.
 SPLATE
 PLATE
 PRESSURE
 FABRICATION
 TEMPERATURE
 PLYORDER
 UNSYMMETRICAL
 ENDOPTION
    4
    2
    4   9   9   4
       0.       2.
    2
    2
   10   1   1   1   5  10
      1.0
    0
    0
    6
    5   5
    8
       0. -1.0420  5.9100  0.1250
       0. -0.5230  5.9775  0.1250
       0.      0.  6.0000  0.1250
       0.  0.5230  5.9775  0.1250
       0.  1.0420  5.9100  0.1250
    0
       2. -1.0420  5.9100  0.1250
       2. -0.5230  5.9775  0.1250
       2.      0.  6.0000  0.1250
       2.  0.5230  5.9775  0.1250
       2.  1.0420  5.9100  0.1250
        0.0     100.0        0.0     100.0        0.0     100.0
 SICA TI15    0.03125        0.0      0.40        0.0
        0.0     100.0        0.0     100.0        0.0     100.0
 SICA TI15    0.03125        0.0      0.40       45.0
        0.0     100.0        0.0     100.0        0.0     100.0
 SICA TI15    0.03125        0.0      0.40      -45.0
        0.0     100.0        0.0     100.0        0.0     100.0
```

INPUT DECK SETUP FOR PROBLEM # 12-A (CONTINUED)

```
FILE: SYNUMCF   DEMO     A1                 VM/SP CONVERSATIONAL MONITOR

 SICA TI15    0.03125      0.0       0.40       90.0
    4   3
    1   2
        0.      120.      240.      360.      480.      600.      660
      780.      840.
       70.       70.      00.0       00.
       70.       70.      00.0       00.
       70.       70.      00.0       00.
       70.       70.      00.0       00.
       70.       70.      00.0       00.
       70.       70.      00.0       00.
       70.       70.      00.0       00.
       70.       70.      00.0       00.
       70.       70.      00.0       00.
       70.       70.      00.0       00.
       70.       70.      00.0      500.
       70.       70.      00.0      500.
       70.       70.      00.0      500.
       70.       70.      00.0      500.
       70.       70.      00.0      500.
       70.       70.      00.0      500.
       70.       70.      00.0      500.
       70.       70.      00.0      500.
       70.       70.      00.0      500.
       70.       70.      00.0      500.
      380.      380.     000.0     1000.
      380.      380.     000.0     1000.
      380.      380.     000.0     1000.
      380.      380.     000.0     1000.
      380.      380.     000.0     1000.
      380.      380.     000.0     1000.
      380.      380.     000.0     1000.
      380.      380.     000.0     1000.
      380.      380.     000.0     1000.
      380.      380.     000.0     1000.
      690.      690.      00.0     1500.
      690.      690.      00.0     1500.
      690.      690.      00.0     1500.
      690.      690.      00.0     1500.
      690.      690.      00.0     1500.
      690.      690.      00.0     1500.
      690.      690.      00.0     1500.
      690.      690.      00.0     1500.
      690.      690.      00.0     1500.
      690.      690.      00.0     1500.
```

INPUT DECK SETUP FOR PROBLEM # 12-A (CONTINUED)

FILE: SYNUMCF DEMO A1 VM/SP CONVERSATIONAL MONITOR

1000.	1000.	000.0	2000.
1000.	1000.	000.0	2000.
1000.	1000.	000.0	2000.
1000.	1000.	000.0	2000.
1000.	1000.	000.0	2000.
1000.	1000.	000.0	2000.
1000.	1000.	000.0	2000.
1000.	1000.	000.0	2000.
1000.	1000.	000.0	2000.
1000.	1000.	000.0	2000.
1000.	1000.	0.	0.
1000.	1000.	0.	0.
1000.	1000.	0.	0.
1000.	1000.	0.	0.
1000.	1000.	0.	0.
1000.	1000.	0.	0.
1000.	1000.	0.	0.
1000.	1000.	0.	0.
1000.	1000.	0.	0.
1000.	1000.	0.	0.
800.	800.	0.	0.
800.	800.	0.	0.
800.	800.	0.	0.
800.	800.	0.	0.
800.	800.	0.	0.
800.	800.	0.	0.
800.	800.	0.	0.
800.	800.	0.	0.
800.	800.	0.	0.
800.	800.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.

INPUT DECK SETUP FOR PROBLEM # 12-A (CONTINUED)

```
FILE: SYNUMCF    DEMO    A1                    VM/SP CONVERSATIONAL MONITOR

        400.      400.      0.        0.
        400.      400.      0.        0.
        400.      400.      0.        0.
        400.      400.      0.        0.
        400.      400.      0.        0.
        200.      200.      0.        0.
        200.      200.      0.        0.
        200.      200.      0.        0.
        200.      200.      0.        0.
        200.      200.      0.        0.
        200.      200.      0.        0.
        200.      200.      0.        0.
        200.      200.      0.        0.
        200.      200.      0.        0.
        200.      200.      0.        0.

    41  41   0   1
    41  41   0   2
    41  41   0   3
    41  41   0   4
    41  41   0   5
    41  41   0   6
     1  81
     1  81
     5   5
     4   4
        0.0       600.0     840.0
```

SAMPLE OUTPUT FOR PROBLEM # 12-A(Fabrication Load)

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 0 DEG. AT TOP)

```
FILE: SYNUMCF   OUT    A              VM/SP CONVERSATIONAL MONITOR SYSTEM              PAGE 00001

TIME                    600.0000000
TOTAL DISPLACEMENTS FOR SELECTED NODES
```

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
5	0.307E-02	-0.353E-04	-0.145E-02	0.152E-02	-0.301E-02	0.350E-04

INPUT DECK SETUP FOR PROBLEM # 12-B (External Load)

FILE: SYNUMCF1 DEMO A1 VM/SP CONVERSATIONAL MONITOR

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 5

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.323E+04	0.962E+03	0.000E+00	0.966E+03	-0.505E+01	0.142E+02
2	-0.501E+04	0.181E+04	0.000E+00	0.145E+03	-0.139E+02	-0.292E+02
3	-0.506E+04	0.179E+04	0.000E+00	-0.154E+04	-0.292E+02	0.139E+02
4	-0.171E+02	-0.599E+03	0.000E+00	0.975E+03	-0.142E+02	-0.505E+01

NODE # 5
MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 600.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	-0.2231E+05	SIGM11A	0.1480E+05	SIGD11B	0.1369E+04	SIGL11	-0.1709E+0[illegible]
3	SIGF22	-0.1491E+05	SIGM22A	0.2400E+05	SIGD22B	0.3035E+04	SIGL22	-0.5989E+0[illegible]
4	SIGF12	0.6964E+04	SIGM22B	0.1953E+05	SIGD22C	-0.1910E+04	SIGL33	0.0000E+00
5	SIGF23	-0.3759E+02	SIGM22C	-0.1491E+05	SIGD12B	0.3720E+03	SIGL12	0.9754E+03
6	SIGF13	-0.1013E+03	SIGM12A	0.5778E+03	SIGD12C	0.4348E+03	SIGL23	-0.1420E+02
7	SIGF33	-0.1413E+05	SIGM12B	0.1033E+04	SIGD23B	-0.1835E+01	SIGL13	-0.5048E+01
8			SIGM12C	0.1202E+04	SIGD23C	-0.2146E+01		
9			SIGM23A	-0.3105E+01	SIGD13B	-0.5405E+01		
10			SIGM23B	-0.5571E+01	SIGD13C	-0.6321E+01		
11			SIGM23C	-0.6483E+01	SIGD33B	0.3109E+04		
12			SIGM13A	-0.8387E+01	SIGD33C	-0.1827E+04		
13			SIGM13B	-0.1507E+02	SIGD11C	0.1369E+04		
14			SIGM13C	-0.1757E+02				
15			SIGM33A	0.2434E+05				
16			SIGM33B	0.2021E+05				
17			SIGM33C	-0.1413E+05				
18			SIGM11B	0.1480E+05				
19			SIGM11C	0.1480E+05				

TIME REQUIRED TO CARRY OUT THE ANALYSIS 350.327 SEC.

TIME REQUIRED TO : READ IN DATA 0.033 SEC.
DO PREPROCESSING 0.049 SEC.

TITLE=PROBLEM #12B,MODAL & LOAD STEPPING(SENSITIVITY)ANALYSIS FOR CUR
TITLE=PANEL(20 deg. SHELL ROOF),FIXED STRAIGHT EDGES,FREE CURVED EDGE
TITLE=EXTERNAL PRESSURE(2000 PSI),UNIFORM TEMP. of 1000 F(REF. TEMP.
TITLE=F),R=6",W=2",T=.125",4(0/45/-45/90)PLIES,FVR=.4,8X8 MESH,
TITLE=FABRICATION EFFECTS INCLUDED, NO FIBER DEGRADATION EFFECTS.

INPUT DECK SETUP FOR PROBLEM # 12-B (CONTINUED)

```
FILE: SYNUMCF1   DEMO    A1                    VM/SP CONVERSATIONAL MONITOR

 SPLATE
 PLATE
 PRESSURE
 RESTART
 TEMPERATURE
 PLYORDER
 UNSYMMETRICAL
 ENDOPTION
    4
    2
    4    9    9    4
         0.        2.
    2
    2
   10    1    1    1   10   10
       7.0
    0
    0
   11
    5    5
    8
         0. -1.0420  5.9100  0.1250
         0. -0.5230  5.9775  0.1250
         0.      0.  6.0000  0.1250
         0.  0.5230  5.9775  0.1250
         0.  1.0420  5.9100  0.1250
    0
         2. -1.0420  5.9100  0.1250
         2. -0.5230  5.9775  0.1250
         2.      0.  6.0000  0.1250
         2.  0.5230  5.9775  0.1250
         2.  1.0420  5.9100  0.1250
          0.0      100.0        0.0      100.0        0.0      100.0
 SICA TI15     0.03125        0.0       0.40        0.0
          0.0      100.0        0.0      100.0        0.0      100.0
 SICA TI15     0.03125        0.0       0.40       45.0
          0.0      100.0        0.0      100.0        0.0      100.0
 SICA TI15     0.03125        0.0       0.40      -45.0
          0.0      100.0        0.0      100.0        0.0      100.0
 SICA TI15     0.03125        0.0       0.40       90.0
    4    3
    1    2
           0.       120.       240.       360.       480.       600.       660
         780.       840.
```

INPUT DECK SETUP FOR PROBLEM # 12-B (CONTINUED)

FILE: SYNUMCF1 DEMO A1 VM/SP CONVERSATIONAL MONITOR

70.	70.	00.0	00.
70.	70.	00.0	00.
70.	70.	00.0	00.
70.	70.	00.0	00.
70.	70.	00.0	00.
70.	70.	00.0	00.
70.	70.	00.0	00.
70.	70.	00.0	00.
70.	70.	00.0	00.
70.	70.	00.0	00.
70.	70.	00.0	500.
70.	70.	00.0	500.
70.	70.	00.0	500.
70.	70.	00.0	500.
70.	70.	00.0	500.
70.	70.	00.0	500.
70.	70.	00.0	500.
70.	70.	00.0	500.
70.	70.	00.0	500.
70.	70.	00.0	500.
380.	380.	000.0	1000.
380.	380.	000.0	1000.
380.	380.	000.0	1000.
380.	380.	000.0	1000.
380.	380.	000.0	1000.
380.	380.	000.0	1000.
380.	380.	000.0	1000.
380.	380.	000.0	1000.
380.	380.	000.0	1000.
380.	380.	000.0	1000.
690.	690.	00.0	1500.
690.	690.	00.0	1500.
690.	690.	00.0	1500.
690.	690.	00.0	1500.
690.	690.	00.0	1500.
690.	690.	00.0	1500.
690.	690.	00.0	1500.
690.	690.	00.0	1500.
690.	690.	00.0	1500.
690.	690.	00.0	1500.
1000.	1000.	000.0	2000.
1000.	1000.	000.0	2000.
1000.	1000.	000.0	2000.
1000.	1000.	000.0	2000.
1000.	1000.	000.0	2000.

INPUT DECK SETUP FOR PROBLEM # 12-B (CONTINUED)

FILE: SYNUMCFI DEMO A1 VM/SP CONVERSATIONAL MONITOR

1000.	1000.	000.0	2000.
1000.	1000.	000.0	2000.
1000.	1000.	000.0	2000.
1000.	1000.	000.0	2000.
1000.	1000.	000.0	2000.
1000.	1000.	0.	0.
1000.	1000.	0.	0.
1000.	1000.	0.	0.
1000.	1000.	0.	0.
1000.	1000.	0.	0.
1000.	1000.	0.	0.
1000.	1000.	0.	0.
1000.	1000.	0.	0.
1000.	1000.	0.	0.
1000.	1000.	0.	0.
800.	800.	0.	0.
800.	800.	0.	0.
800.	800.	0.	0.
800.	800.	0.	0.
800.	800.	0.	0.
800.	800.	0.	0.
800.	800.	0.	0.
800.	800.	0.	0.
800.	800.	0.	0.
800.	800.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
200.	200.	0.	0.
200.	200.	0.	0.

SAMPLE OUTPUT FOR PROBLEM # 12 B(External Load)

```
   200.      200.      0.      0.
   200.      200.      0.      0.
   200.      200.      0.      0.
   200.      200.      0.      0.
   200.      200.      0.      0.
   200.      200.      0.      0.
   200.      200.      0.      0.
   200.      200.      0.      0.

 1  73   9   2
 1  73   9   3
 1  73   9   4
 1  73   9   5
 1  73   9   6
 9  81   9   2
 9  81   9   3
 9  81   9   4
 9  81   9   5
 9  81   9   6
37  45   8   1
 1  81
 1  81
 5   5
 4   4
    0.0      600.0      840.0
```

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 0 DEG. AT TOP)

FILE: SYNUMCF1 OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

TIME 660.0000000

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
5	0.295E-02	-0.334E-04	-0.573E-02	0.157E-02	-0.422E-02	-0.229E-04

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 5

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	0.522E+04	0.230E+04	0.000E+00	0.772E+03	-0.319E+02	0.636E+02
2	-0.823E+04	0.199E+03	0.000E+00	0.232E+04	-0.481E+02	-0.145E+03
3	-0.147E+05	-0.526E+04	0.000E+00	-0.775E+04	-0.145E+03	0.481E+02
4	0.109E+04	-0.219E+05	0.000E+00	0.134E+04	-0.636E+02	-0.319E+02

SAMPLE OUTPUT FOR PROBLEM # 12-B (CONTINUED)

NODE # 5
MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 660.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	-0.1235E+05	SIGM11A	0.1002E+05	SIGD11B	0.6363E+04	SIGL11	0.1094E+04
3	SIGF22	-0.3954E+05	SIGM22A	0.1059E+05	SIGD22B	-0.2378E+05	SIGL22	-0.2194E+05
4	SIGF12	0.9252E+04	SIGM22B	-0.4278E+04	SIGD22C	-0.2464E+05	SIGL33	0.0000E+00
5	SIGF23	-0.2220E+03	SIGM22C	-0.3954E+05	SIGD12B	0.1180E+04	SIGL12	0.1341E+04
6	SIGF13	-0.4115E+03	SIGM12A	0.7993E+03	SIGD12C	0.1377E+04	SIGL23	-0.6363E+02
7	SIGF33	-0.1478E+05	SIGM12B	0.1414E+04	SIGD23B	-0.9427E+02	SIGL13	-0.3187E+02
8			SIGM12C	0.1648E+04	SIGD23C	-0.1102E+03		
9			SIGM23A	-0.2085E+02	SIGD13B	-0.1588E+03		
10			SIGM23B	-0.3644E+02	SIGD13C	-0.1857E+03		
11			SIGM23C	-0.4258E+02	SIGD33B	-0.4337E+03		
12			SIGM13A	-0.3826E+02	SIGD33C	-0.6762E+03		
13			SIGM13B	-0.6708E+02	SIGD11C	0.6351E+04		
14			SIGM13C	-0.7839E+02				
15			SIGM33A	0.2476E+05				
16			SIGM33B	0.1977E+05				
17			SIGM33C	-0.1478E+05				
18			SIGM11B	0.1002E+05				
19			SIGM11C	0.1002E+05				

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 0 DEG. AT TOP)

FILE: SYNUMCF1 OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

TIME 720.0000000

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
5	0.163E-02	-0.356E-04	-0.597E-02	0.160E-02	-0.316E-02	-0.247E-04

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 5

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.221E+05	0.362E+04	0.000E+00	0.797E+03	-0.676E+02	0.400E+02
2	-0.193E+05	-0.882E+04	0.000E+00	0.113E+05	0.419E+02	-0.163E+03
3	-0.273E+05	-0.156E+05	0.000E+00	-0.165E+05	-0.163E+03	-0.419E+02
4	0.394E+04	-0.419E+05	0.000E+00	0.147E+04	-0.400E+02	-0.676E+02

NODE # 5
MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 720.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	0.1033E+05	SIGM11A	-0.3432E+03	SIGD11B	0.6402E+04	SIGL11	0.3939E+0

SAMPLE OUTPUT FOR PROBLEM # 12 B (CONTINUED)

3	SIGF22	-0.5688E+05	SIGM22A	-0.9809E+04	SIGD22B	-0.2654E+05	SIGL22	-0.4189E+05
4	SIGF12	0.1011E+05	SIGM22B	-0.3082E+05	SIGD22C	-0.1738E+05	SIGL33	0.0000E+00
5	SIGF23	-0.4955E+03	SIGM22C	-0.5688E+05	SIGD12B	0.4364E+03	SIGL12	0.1466E+04
6	SIGF13	-0.2499E+03	SIGM12A	0.8740E+03	SIGD12C	0.5074E+03	SIGL23	-0.3996E+02
7	SIGF33	-0.1087E+05	SIGM12B	0.1543E+04	SIGD23B	-0.1372E+03	SIGL13	-0.6762E+02
8			SIGM12C	0.1805E+04	SIGD23C	-0.1602E+03		
9			SIGM23A	-0.4456E+02	SIGD13B	0.8131E+02		
10			SIGM23B	-0.7864E+02	SIGD13C	0.9493E+02		
11			SIGM23C	-0.9191E+02	SIGD33B	-0.7489E+04		
12			SIGM13A	-0.2422E+02	SIGD33C	0.3933E+04		
13			SIGM13B	-0.4206E+02	SIGD11C	0.6515E+04		
14			SIGM13C	-0.4917E+02				
15			SIGM33A	0.1731E+05				
16			SIGM33B	0.1231E+05				
17			SIGM33C	-0.1087E+05				
18			SIGM11B	-0.3432E+03				
19			SIGM11C	-0.3432E+03				

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 0 DEG. AT TOP)

FILE: SYNUMCF1 OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

TIME 780.0000000

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
5	0.206E-03	-0.383E-04	-0.645E-02	0.165E-02	-0.184E-02	-0.306E-04

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 5

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.493E+05	0.530E+04	0.000E+00	0.773E+03	-0.992E+02	0.147E+02
2	-0.299E+05	-0.177E+05	0.000E+00	0.197E+05	0.128E+03	-0.173E+03
3	-0.395E+05	-0.259E+05	0.000E+00	-0.246E+05	-0.173E+03	-0.128E+03
4	0.727E+04	-0.607E+05	0.000E+00	0.161E+04	-0.147E+02	-0.992E+02

NODE # 5

MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 780.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	0.3750E+05	SIGM11A	-0.1293E+05	SIGD11B	0.9032E+04	SIGL11	0.7265E+04
3	SIGF22	-0.7285E+05	SIGM22A	-0.2887E+05	SIGD22B	-0.2377E+05	SIGL22	-0.6066E+05
4	SIGF12	0.1116E+05	SIGM22B	-0.5457E+05	SIGD22C	-0.1595E+05	SIGL33	0.0000E+00
5	SIGF23	-0.7850E+03	SIGM22C	-0.7285E+05	SIGD12B	0.5285E+03	SIGL12	0.1605E+04
6	SIGF13	-0.5690E+02	SIGM12A	0.9554E+03	SIGD12C	0.6120E+03	SIGL23	-0.1472E+02
7	SIGF33	-0.6704E+04	SIGM12B	0.1689E+04	SIGD23B	-0.1426E+03	SIGL13	-0.9917E+02
8			SIGM12C	0.1972E+04	SIGD23C	-0.1659E+03		

9			SIGM23A	-0.6674E+02	SIGD13B	0.9491E+02		
10			SIGM23B	-0.1191E+03	SIGD13C	0.1104E+03		
11			SIGM23C	-0.1390E+03	SIGD33B	-0.6906E+04		
12			SIGM13A	-0.9462E+01	SIGD33C	0.4196E+04		
13			SIGM13B	-0.1516E+02	SIGD11C	0.9132E+04		
14			SIGM13C	-0.1786E+02				
15			SIGM33A	0.9303E+04				
16			SIGM33B	0.5393E+04				
17			SIGM33C	-0.6704E+04				
18			SIGM11B	-0.1293E+05				
19			SIGM11C	-0.1293E+05				

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 0 DEG. AT TOP)

FILE: SYNUMCF1 OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

TIME 840.0000000

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
5	-0.115E-02	-0.465E-04	-0.795E-02	0.165E-02	0.909E-03	-0.441E-04

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 5

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.642E+05	0.759E+04	0.000E+00	0.530E+03	-0.660E+02	-0.273E+02
2	-0.382E+05	-0.273E+05	0.000E+00	0.275E+05	0.142E+03	-0.586E+02
3	-0.545E+05	-0.405E+05	0.000E+00	-0.334E+05	-0.586E+02	-0.142E+03
4	0.127E+05	-0.757E+05	0.000E+00	0.224E+04	0.273E+02	-0.660E+02

NODE # 5

MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 840.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	0.8461E+05	SIGM11A	-0.3527E+05	SIGD11B	0.1007E+05	SIGL11	0.1269E+05
3	SIGF22	-0.6676E+05	SIGM22A	-0.5220E+05	SIGD22B	-0.3104E+05	SIGL22	-0.7572E+05
4	SIGF12	0.1682E+05	SIGM22B	-0.8564E+05	SIGD22C	0.6036E+04	SIGL33	0.0000E+00
5	SIGF23	-0.2278E+03	SIGM22C	0.0000E+00	SIGD12B	0.2743E+04	SIGL12	0.2240E+04
6	SIGF13	0.3173E+03	SIGM12A	0.1318E+04	SIGD12C	0.3155E+04	SIGL23	0.2734E+02
7	SIGF33	-0.1689E+04	SIGM12B	0.2377E+04	SIGD23B	0.2683E+03	SIGL13	-0.6605E+02
8			SIGM12C	0.2759E+04	SIGD23C	0.3099E+03		
9			SIGM23A	-0.3097E+02	SIGD13B	0.1802E+03		
10			SIGM23B	-0.5125E+02	SIGD13C	0.2082E+03		
11			SIGM23C	-0.6073E+02	SIGD33B	-0.1010E+05		
12			SIGM13A	0.1453E+02	SIGD33C	0.5011E+04		

SAMPLE OUTPUT FOR PROBLEM # 12-B (CONTINUED)

```
13                                  SIGM13B     0.3030E+02      SIGD11C     0.1045E+05
14                                  SIGM13C     0.3467E+02
15                                  SIGM33A    -0.4089E+03
16                                  SIGM33B    -0.4714E+04
17                                  SIGM33C    -0.1689E+04
18                                  SIGM11B    -0.3527E+05
19                                  SIGM11C    -0.3527E+05
-------------------------------------------------------------------------------------------------

TIME REQUIRED TO CARRY OUT THE ANALYSIS       276.556 SEC.

TIME REQUIRED TO : READ IN DATA               0.033 SEC.
                   DO PREPROCESSING           0.049 SEC.
```

DEMONSTRATION PROBLEM NO. 13

PROBLEM TYPE:

Load stepping analysis of a hollow sandwich type built-up structure using plate element subjected to thermo-mechanical loading including fabrication load history.

PROBLEM DESCRIPTION:

A hollow built-up structure of 0.5" length, 0.2" width, 0.075" total thickness, 0.02" thickness of top plate, 0.01" thickness of bottom plate, and 3 spars in the x-z plane equally spaced in the y-direction with 0.02" thickness the z-direction, with bottom surface fixed in vertical direction, is subjected to 4 load steps of internal pressure (0-2000 psi) and uniform temperature increase (70-1000 F). The built-up structure is made of Sic/Ti-15-3-3-3 composite material (Silicon Carbide fiber, Titanium matrix with 15% Vanadium, 3% Aluminum, 3% Chromium, and 3% Tin, and interphase with average properties of fiber and matrix). The composite laminate consists of 4 (90/0/0/90) plies of equal thickness for the top plate, 2 (90/90) plies of equal thickness for the bottom plate, and 4 (0/0/0/0) plies of equal thickness for the spars, all with 0.4 fiber volume ratio. The ply lay-up is symmetric for all parts of the structure. The ply lay-up is same as that used for problem # 5 shown on pages 33-34. The material properties at the reference temperature of 70 F are listed in Table II. The exponents for material property variations according to the nonlinear multi-factor interaction model (Ref. 1) are listed in Table III. Results are to be generated for the displacement and stress responses at each load step including the fabrication load history accounting for the nonlinear material behavior. The geometry, boundary conditions, loading, and ply lay-up are shown in the figure on next page.

MODELING HINTS:

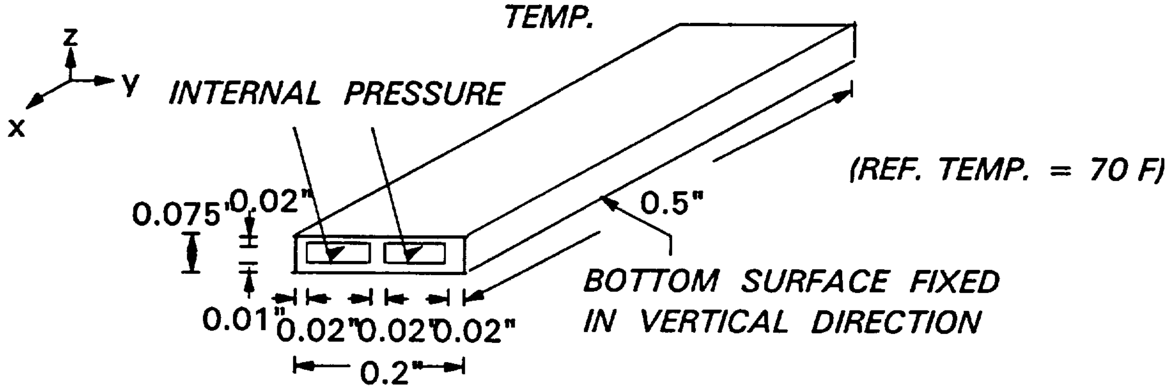
The finite element mesh consists of 4 elements in the x-direction and 8 in the y-direction for both the top and bottom plates and 4 elements in the x-direction and 1 element in the z-direction for all each of the 3 spars. The mesh is same as that used for problem # 5 shown on pages 35-36. The material property data file, "DATA BANK" is included in Appendix 1.

PROBLEM # 13

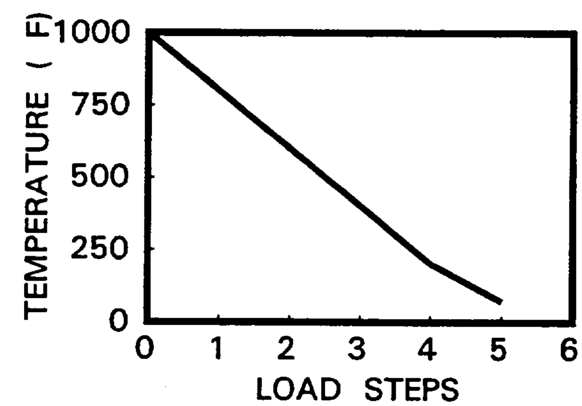
ƎOTTOM SUPPORTED BUILT-UP STRUCTURE UNDER BENDING & UNIFORM TEMP. LOADINGS FOLLOWED BY FABRICATION THERMAL COOLING LOAD

FOR (Si C/Ti-15-3-3-3, TOP:$[90,0]_s$, BOTTOM:$[90]_s$, SPARS:$4[0]_s$); 0.4 FIBER VOLUME RATIO

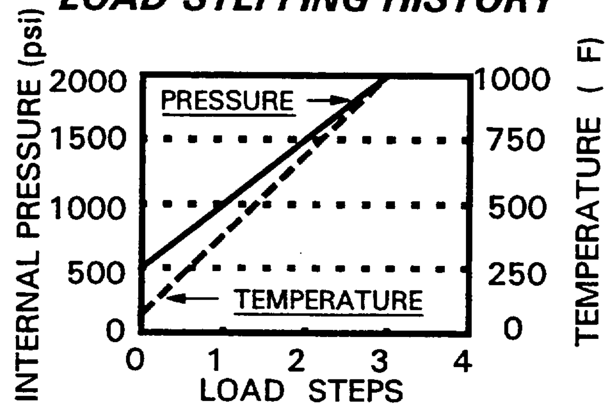
GEOMETRY, BOUNDARY CONDITIONS, AND LOADING



FABRICATION THERMAL COOLING LOAD HISTORY



LOAD STEPPING HISTORY



INPUT DECK SETUP FOR PROBLEM # 13-A (Fabrication Load)

FILE: UYNUMCF DEMO A1 VM/SP CONVERSATIONAL MONITOR

```
TITLE=PROB # 13-A,PANEL,BOTTOM FIXED IN Z-DIRECTION+,INSIDE AT 1000F&
TITLE=2000 psi, OUTSIDE AT 1000F & 0 PSI,4X8(TOP)-8(BOT)-12(SPAR)MESH
TITLE=3 SPARS-.02" THICK-4(1,-1,-1,1)PLY TYPE,TOP-.02"-4(1,2,2,1)PLIE
TITLE=BOTTOM-.01"-2(2,2)PLIES,L=.5",W=.2",H=.075",LINC=2
TITLE=FABRICATION(1000 TO 70 F),NO FIBER DEGRADATION.
HPLATE
PLATE
FABRICATION
PROFILE
PLYORDER
TEMPERATURE
PRESSURE
PANEL
ENDOPTION
   2
   2   2   3   7
   2
   3   3
  10   1   1   1   5  10
     1.0
   0
   0
   6
   1   1   1
   2  0.00
     0.000       .02     0.000       .02     0.000       .02
   2  0.25
     0.000       .02     0.000       .02     0.000       .02
      0.50
     0.000       .02     0.000       .02     0.000       .02
   3   3   3
   3   3   3
    0.0000   -0.1000    0.0400    0.0200
    0.0000    0.0000    0.0400    0.0200
    0.0000    0.1000    0.0400    0.0200
    0.2500   -0.1000    0.0400    0.0200
    0.2500    0.0000    0.0400    0.0200
    0.2500    0.1000    0.0400    0.0200
    0.5000   -0.1000    0.0400    0.0200
    0.5000    0.0000    0.0400    0.0200
    0.5000    0.1000    0.0400    0.0200
    0.0000   -0.1000   -0.0350    0.0100
    0.0000    0.0000   -0.0350    0.0100
    0.0000    0.1000   -0.0350    0.0100
    0.2500   -0.1000   -0.0350    0.0100
    0.2500    0.0000   -0.0350    0.0100
    0.2500    0.1000   -0.0350    0.0100
    0.5000   -0.1000   -0.0350    0.0100
    0.5000    0.0000   -0.0350    0.0100
    0.5000    0.1000   -0.0350    0.0100
```

INPUT DECK SETUP FOR PROBLEM # 13-A (CONTINUED)

```
FILE: UYNUMCF   DEMO     A1                 VM/SP CONVERSATIONAL MONITOR


      0.0       0.0       0.0     100.0       0.0     100.0
 SICA TI15    .00500      0.0      0.40       0.0
      0.0       0.0       0.0     100.0       0.0     100.0
 SICA TI15    .00500      0.0      0.40      90.0
   2    1
       0.      120.      240.      360.      480.      600.      660
     780.      840.
    1000.     1000.        0.        0.
    1000.     1000.        0.        0.
    1000.     1000.        0.        0.
    1000.     1000.        0.        0.
    1000.     1000.        0.        0.
    1000.     1000.        0.        0.
    1000.     1000.        0.        0.
    1000.     1000.        0.        0.
    1000.     1000.        0.        0.
    1000.     1000.        0.        0.
    1000.     1000.        0.        0.
    1000.     1000.        0.        0.
    1000.     1000.        0.        0.
    1000.     1000.        0.        0.
    1000.     1000.        0.        0.
    1000.     1000.        0.        0.
    1000.     1000.        0.        0.
    1000.     1000.        0.        0.
     800.      800.        0.        0.
     800.      800.        0.        0.
     800.      800.        0.        0.
     800.      800.        0.        0.
     800.      800.        0.        0.
     800.      800.        0.        0.
     800.      800.        0.        0.
     800.      800.        0.        0.
     800.      800.        0.        0.
     800.      800.        0.        0.
     800.      800.        0.        0.
     800.      800.        0.        0.
     800.      800.        0.        0.
     800.      800.        0.        0.
     800.      800.        0.        0.
     800.      800.        0.        0.
     800.      800.        0.        0.
     800.      800.        0.        0.
     600.      600.        0.        0.
     600.      600.        0.        0.
     600.      600.        0.        0.
     600.      600.        0.        0.
     600.      600.        0.        0.
     600.      600.        0.        0.
     600.      600.        0.        0.
     600.      600.        0.        0.
```

INPUT DECK SETUP FOR PROBLEM # 13-A (CONTINUED)

FILE: UYNUMCF DEMO A1 VM/SP CONVERSATIONAL MONITOR

600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
600.	600.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
400.	400.	0.	0.
200.	200.	0.	0.
200.	200.	0.	0.
200.	200.	0.	0.
200.	200.	0.	0.
200.	200.	0.	0.
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200.	200.	0.	0.
70.	70.	0.	00.
70.	70.	0.	00.
70.	70.	0.	00.
70.	70.	0.	00.
70.	70.	0.	00

INPUT DECK SETUP FOR PROBLEM # 13-A (CONTINUED)

```
FILE: UYNUMCF   DEMO    A1                  VM/SP CONVERSATIONAL MONITOR


       70.        70.        0.        00.
       70.        70.        0.        00.
       70.        70.        0.        00.
       70.        70.        0.        00.
       70.        70.        0.        00.
       70.        70.        0.        00.
       70.        70.        0.        00.
       70.        70.        0.        00.
       70.        70.        0.        00.
       70.        70.        0.        00.
       70.        70.        0.        00.
       70.        70.        0.        00.
       70.        70.        0.        00.
       70.        70.        0.       500.
       70.        70.        0.       500.
       70.        70.        0.       500.
       70.        70.        0.       500.
       70.        70.        0.       500.
       70.        70.        0.       500.
       70.        70.        0.       500.
       70.        70.        0.       500.
       70.        70.        0.       500.
       70.        70.      500.        00.
       70.        70.      500.        00.
       70.        70.      500.        00.
       70.        70.      500.        00.
       70.        70.      500.        00.
       70.        70.      500.        00.
       70.        70.      500.        00.
       70.        70.      500.        00.
       70.        70.      500.        00.
      380.       380.        0.      1000.
      380.       380.        0.      1000.
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      380.       380.        0.      1000.
      380.       380.        0.      1000.
      380.       380.        0.      1000.
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      380.       380.        0.      1000.
      380.       380.        0.      1000.
      380.       380.     1000.       000.
      380.       380.     1000.       000.
      380.       380.     1000.       000.
      380.       380.     1000.       000.
      380.       380.     1000.       000.
      380.       380.     1000.       000.
      380.       380.     1000.       000.
      380.       380.     1000.       000.
      380.       380.     1000.       000.
```

INPUT DECK SETUP FOR PROBLEM # 13-A (CONTINUED)

```
FILE: UYNUMCF   DEMO    A1                 VM/SP CONVERSATIONAL MONITOR


         690.      690.         0.     1500.
         690.      690.         0.     1500.
         690.      690.         0.     1500.
         690.      690.         0.     1500.
         690.      690.         0.     1500.
         690.      690.         0.     1500.
         690.      690.         0.     1500.
         690.      690.         0.     1500.
         690.      690.         0.     1500.
         690.      690.      1500.       00.
         690.      690.      1500.       00.
         690.      690.      1500.       00.
         690.      690.      1500.       00.
         690.      690.      1500.       00.
         690.      690.      1500.       00.
         690.      690.      1500.       00.
         690.      690.      1500.       00.
         690.      690.      1500.       00.
        1000.     1000.         0.     2000.
        1000.     1000.         0.     2000.
        1000.     1000.         0.     2000.
        1000.     1000.         0.     2000.
        1000.     1000.         0.     2000.
        1000.     1000.         0.     2000.
        1000.     1000.         0.     2000.
        1000.     1000.         0.     2000.
        1000.     1000.         0.     2000.
        1000.     1000.      2000.      000.
        1000.     1000.      2000.      000.
        1000.     1000.      2000.      000.
        1000.     1000.      2000.      000.
        1000.     1000.      2000.      000.
        1000.     1000.      2000.      000.
        1000.     1000.      2000.      000.
        1000.     1000.      2000.      000.
        1000.     1000.      2000.      000.
    41   41    0    1
    41   41    0    2
    41   41    0    3
    41   41    0    4
    41   41    0    5
    41   41    0    6
     1   12
     1   12
     3    3   12   12
     4    4
         0.     600.     840.
```

SAMPLE OUTPUT FOR PROBLEM # 13-A(Fabrication Load)

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 90 DEG. AT TOP)

FILE: UYNUMCF OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

TIME 600.0000000

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
12	0.781E-03	0.150E-03	0.220E-03	-0.104E-03	-0.199E-03	-0.273E-04

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 3

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.406E+04	0.381E+04	0.000E+00	0.127E+03	0.102E+02	-0.105E+01
2	-0.268E+04	0.307E+04	0.000E+00	-0.111E+03	0.224E+01	0.218E+02
3	-0.262E+04	0.297E+04	0.000E+00	-0.943E+02	0.224E+01	0.218E+02
4	-0.468E+04	0.386E+04	0.000E+00	0.779E+02	0.102E+02	-0.105E+01

1NODE # 3

MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 600.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	-0.3356E+05	SIGM11A	0.1462E+05	SIGD11B	0.5669E+03	SIGL11	-0.4681E+04
3	SIGF22	-0.9195E+04	SIGM22A	0.2650E+05	SIGD22B	0.3588E+04	SIGL22	0.3864E+04
4	SIGF12	0.5546E+03	SIGM22B	0.2439E+05	SIGD22C	-0.1245E+04	SIGL33	0.0000E+00
5	SIGF23	-0.7757E+01	SIGM22C	-0.9195E+04	SIGD12B	0.3198E+02	SIGL12	0.7786E+02
6	SIGF13	0.7282E+02	SIGM12A	0.4602E+02	SIGD12C	0.3743E+02	SIGL23	0.1017E+02
7	SIGF33	-0.1401E+05	SIGM12B	0.8257E+02	SIGD23B	-0.4226E+00	SIGL13	-0.1047E+01
8			SIGM12C	0.9625E+02	SIGD23C	-0.4942E+00		
9			SIGM23A	-0.6435E+00	SIGD13B	0.3689E+01		
10			SIGM23B	-0.1158E+01	SIGD13C	0.4314E+01		
11			SIGM23C	-0.1342E+01	SIGD33B	0.3119E+04		
12			SIGM13A	0.6014E+01	SIGD33C	-0.1813E+04		
13			SIGM13B	0.1080E+02	SIGD11C	0.5661E+03		
14			SIGM13C	0.1261E+02				
15			SIGM33A	0.2423E+05				
16			SIGM33B	0.2032E+05				
17			SIGM33C	-0.1401E+05				
18			SIGM11B	0.1462E+05				
19			SIGM11C	0.1462E+05				

TIME REQUIRED TO CARRY OUT THE ANALYSIS 451.148 SEC.

TIME REQUIRED TO : READ IN DATA 0.054 SEC.
DO PREPROCESSING 0.232 SEC.

INPUT DECK SETUP FOR PROBLEM # 13-B (External Load)

```
FILE: UYNUMCF1  DEMO    A1                    VM/SP CONVERSATIONAL MONITOR

 TITLE=PROB # 13-B,PANEL,BOTTOM FIXED IN Z-DIRECTION+,INSIDE AT 1000F&
 TITLE=2000 psi, OUTSIDE AT 1000F & 0 PSI,4X8(TOP)-8(BOT)-12(SPAR)MESH
 TITLE=3 SPARS-.02" THICK-4(1,-1,-1,1)PLY TYPE,TOP-.02"-4(1,2,2,1)PLIE
 TITLE=BOTTOM-.01"-2(2,2)PLIES,L=.5",W=.2",H=.075",LINC=2
 TITLE=FABRICATION(1000 TO 70 F),NO FIBER DEGRADATION.      ION,
 HPLATE
 PLATE
 FABRICATION
 RESTART
 PROFILE
 PLYORDER
 TEMPERATURE
 PRESSURE
 PANEL
 ENDOPTION
    2
    2   2   3   7
    2
    3   3
   10   1   1   1  10  10
      1.0
    0
    0
    8
    1   1   1
    2  0.00
      0.000       .02     0.000       .02     0.000       .02
    2  0.25
      0.000       .02     0.000       .02     0.000       .02
       0.50
      0.000       .02     0.000       .02     0.000       .02
    3   3   3
    3   3   3
     0.0000   -0.1000    0.0400    0.0200
     0.0000    0.0000    0.0400    0.0200
     0.0000    0.1000    0.0400    0.0200
     0.2500   -0.1000    0.0400    0.0200
     0.2500    0.0000    0.0400    0.0200
     0.2500    0.1000    0.0400    0.0200
     0.5000   -0.1000    0.0400    0.0200
     0.5000    0.0000    0.0400    0.0200
     0.5000    0.1000    0.0400    0.0200
     0.0000   -0.1000   -0.0350    0.0100
     0.0000    0.0000   -0.0350    0.0100
     0.0000    0.1000   -0.0350    0.0100
     0.2500   -0.1000   -0.0350    0.0100
     0.2500    0.0000   -0.0350    0.0100
     0.2500    0.1000   -0.0350    0.0100
     0.5000   -0.1000   -0.0350    0.0100
     0.5000    0.0000   -0.0350    0.0100
     0.5000    0.1000   -0.0350    0.0100
```

INPUT DECK SETUP FOR PROBLEM # 13-B (CONTINUED)

FILE: UYNUMCF1   DEMO   A1   VM/SP CONVERSATIONAL MONITOR

```
       0.0        0.0       0.0     100.0       0.0      100.0
 SICA TI15      .00500      0.0      0.40       0.0
       0.0        0.0       0.0     100.0       0.0      100.0
 SICA TI15      .00500      0.0      0.40      90.0
   2    1
        0.       120.      240.      360.      480.      600.      660
      780.       840.
     1000.      1000.        0.        0.
     1000.      1000.        0.        0.
     1000.      1000.        0.        0.
     1000.      1000.        0.        0.
     1000.      1000.        0.        0.
     1000.      1000.        0.        0.
     1000.      1000.        0.        0.
     1000.      1000.        0.        0.
     1000.      1000.        0.        0.
     1000.      1000.        0.        0.
     1000.      1000.        0.        0.
     1000.      1000.        0.        0.
     1000.      1000.        0.        0.
     1000.      1000.        0.        0.
     1000.      1000.        0.        0.
     1000.      1000.        0.        0.
     1000.      1000.        0.        0.
     1000.      1000.        0.        0.
      800.       800.        0.        0.
      800.       800.        0.        0.
      900.       800.        0.        0.
      800.       800.        0.        0.
      800.       800.        0.        0.
      800.       800.        0.        0.
      800.       800.        0.        0.
      800.       800.        0.        0.
      800.       800.        0.        0.
      800.       800.        0.        0.
      800.       800.        0.        0.
      800.       800.        0.        0.
      800.       800.        0.        0.
      800.       800.        0.        0.
      800.       800.        0.        0.
      800.       800.        0.        0.
      800.       800.        0.        0.
      800.       800.        0.        0.
      600.       600.        0.        0.
      600.       600.        0.        0.
      600.       600.        0.        0.
      600.       600.        0.        0.
      600.       600.        0.        0.
      600.       600.        0.        0.
      600.       600.        0.        0.
      600.       600.        0         0
```

INPUT DECK SETUP FOR PROBLEM # 13-B (CONTINUED)

FILE: UYNUMCF1 DEMO A1 VM/SP CONVERSATIONAL MONITOR

```
     600.      600.        0.        0.
     600.      600.        0.        0.
     600.      600.        0.        0.
     600.      600.        0.        0.
     600.      600.        0.        0.
     600.      600.        0.        0.
     600.      600.        0.        0.
     600.      600.        0.        0.
     600.      600.        0.        0.
     600.      600.        0.        0.
     400.      400.        0.        0.
     400.      400.        0.        0.
     400.      400.        0.        0.
     400.      400.        0.        0.
     400.      400.        0.        0.
     400.      400.        0.        0.
     400.      400.        0.        0.
     400.      400.        0.        0.
     400.      400.        0.        0.
     400.      400.        0.        0.
     400.      400.        0.        0.
     400.      400.        0.        0.
     400.      400.        0.        0.
     400.      400.        0.        0.
     400.      400.        0.        0.
     400.      400.        0.        0.
     400.      400.        0.        0.
     400.      400.        0.        0.
     200.      200.        0.        0.
     200.      200.        0.        0.
     200.      200.        0.        0.
     200.      200.        0.        0.
     200.      200.        0.        0.
     200.      200.        0.        0.
     200.      200.        0.        0.
     200.      200.        0.        0.
     200.      200.        0.        0.
     200.      200.        0.        0.
     200.      200.        0.        0.
     200.      200.        0.        0.
     200.      200.        0.        0.
     200.      200.        0.        0.
     200.      200.        0.        0.
     200.      200.        0.        0.
     200.      200.        0.        0.
     200.      200.        0.        0.
      70.       70.        0.       00.
      70.       70.        0.       00.
      70.       70.        0.       00.
      70.       70.        0.       00.
      70.       70.        0.       00.
```

INPUT DECK SETUP FOR PROBLEM # 13-B (CONTINUED)

FILE: UYNUMCF1 DEMO A1 VM/SP CONVERSATIONAL MONITOR

70.	70.	0.	00.
70.	70.	0.	00.
70.	70.	0.	00.
70.	70.	0.	00.
70.	70.	0.	00.
70.	70.	0.	00.
70.	70.	0.	00.
70.	70.	0.	00.
70.	70.	0.	00.
70.	70.	0.	00.
70.	70.	0.	00.
70.	70.	0.	00.
70.	70.	0.	00.
70.	70.	0.	500.
70.	70.	0.	500.
70.	70.	0.	500.
70.	70.	0.	500.
70.	70.	0.	500.
70.	70.	0.	500.
70.	70.	0.	500.
70.	70.	0.	500.
70.	70.	0.	500.
70.	70.	500.	00.
70.	70.	500.	00.
70.	70.	500.	00.
70.	70.	500.	00.
70.	70.	500.	00.
70.	70.	500.	00.
70.	70.	500.	00.
70.	70.	500.	00.
70.	70.	500.	00.
380.	380.	0.	1000.
380.	380.	0.	1000.
380.	380.	0.	1000.
380.	380.	0.	1000.
380.	380.	0.	1000.
380.	380.	0.	1000.
380.	380.	0.	1000.
380.	380.	0.	1000.
380.	380.	0.	1000.
380.	380.	1000.	000.
380.	380.	1000.	000.
380.	380.	1000.	000.
380.	380.	1000.	000.
380.	380.	1000.	000.
380.	380.	1000.	000.
380.	380.	1000.	000.
380.	380.	1000.	000.
380.	380.	1000.	000.

INPUT DECK SETUP FOR PROBLEM # 13-B (CONTINUED)

FILE: UYNUMCF1 DEMO A1 VM/SP CONVERSATIONAL MONITOR

```
     690.      690.        0.     1500.
     690.      690.        0.     1500.
     690.      690.        0.     1500.
     690.      690.        0.     1500.
     690.      690.        0.     1500.
     690.      690.        0.     1500.
     690.      690.        0.     1500.
     690.      690.        0.     1500.
     690.      690.        0.     1500.
     690.      690.     1500.       00.
     690.      690.     1500.       00.
     690.      690.     1500.       00.
     690.      690.     1500.       00.
     690.      690.     1500.       00.
     690.      690.     1500.       00.
     690.      690.     1500.       00.
     690.      690.     1500.       00.
     690.      690.     1500.       00.
    1000.     1000.        0.     2000.
    1000.     1000.        0.     2000.
    1000.     1000.        0.     2000.
    1000.     1000.        0.     2000.
    1000.     1000.        0.     2000.
    1000.     1000.        0.     2000.
    1000.     1000.        0.     2000.
    1000.     1000.        0.     2000.
    1000.     1000.        0.     2000.
    1000.     1000.     2000.      000.
    1000.     1000.     2000.      000.
    1000.     1000.     2000.      000.
    1000.     1000.     2000.      000.
    1000.     1000.     2000.      000.
    1000.     1000.     2000.      000.
    1000.     1000.     2000.      000.
    1000.     1000.     2000.      000.
    1000.     1000.     2000.      000.
37  46   9   1
45  54   9   1
41  50   9   2
10  18   1   3
28  36   1   3
46  54   1   3
64  72   1   3
82  90   1   3
 1  12
 1  12
 3   3  12  12
 4   4
    0.     600.     840.
```

SAMPLE OUTPUT FOR PROBLEM # 13-B(External Load)

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 90 DEG. AT TOP)

FILE: UYNUMCF1 OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

TIME 660.0000000

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
12	0.783E-03	0.150E-03	0.220E-03	-0.124E-03	-0.191E-03	-0.306E-04

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 3

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.629E+04	0.349E+04	0.000E+00	0.163E+03	0.725E+02	-0.597E+01
2	-0.284E+04	0.273E+04	0.000E+00	-0.136E+03	0.128E+02	0.155E+03
3	-0.268E+04	0.360E+04	0.000E+00	-0.109E+03	0.128E+02	0.155E+03
4	-0.193E+04	0.409E+04	0.000E+00	0.821E+02	0.725E+02	-0.597E+01

NODE # 3

MICROSTRESSES (in psi. units) IN PLY NO.- 4 AT TIME 660.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	-0.2849E+05	SIGM11A	0.1578E+05	SIGD11B	0.3071E+04	SIGL11	-0.1928E+04
3	SIGF22	-0.8880E+04	SIGM22A	0.2662E+05	SIGD22B	0.2375E+03	SIGL22	0.4093E+04
4	SIGF12	0.5817E+03	SIGM22B	0.2465E+05	SIGD22C	0.3204E+03	SIGL33	0.0000E+00
5	SIGF23	-0.4127E+02	SIGM22C	-0.8880E+04	SIGD12B	0.1365E+02	SIGL12	0.8211E+02
6	SIGF13	0.4645E+03	SIGM12A	0.4857E+02	SIGD12C	0.1597E+02	SIGL23	0.7252E+02
7	SIGF33	-0.1338E+05	SIGM12B	0.8707E+02	SIGD23B	-0.1713E+02	SIGL13	-0.5969E+01
8			SIGM12C	0.1015E+03	SIGD23C	-0.2003E+02		
9			SIGM23A	-0.3867E+01	SIGD13B	0.2002E+03		
10			SIGM23B	-0.6769E+01	SIGD13C	0.2342E+03		
11			SIGM23C	-0.7899E+01	SIGD33B	0.5109E+03		
12			SIGM13A	0.4369E+02	SIGD33C	0.6217E+03		
13			SIGM13B	0.7636E+02	SIGD11C	0.3071E+04		
14			SIGM13C	0.8927E+02				
15			SIGM33A	0.2447E+05				
16			SIGM33B	0.2081E+05				
17			SIGM33C	-0.1338E+05				
18			SIGM11B	0.1578E+05				
19			SIGM11C	0.1578E+05				

SAMPLE OUTPUT FOR PROBLEM # 13-B (Continued)

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 90 DEG. AT TOP)

FILE: UYNUMCF1 OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

TIME 720.0000000

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
12	0.531E-03	0.102E-03	0.220E-03	-0.139E-03	-0.177E-03	-0.236E-04

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 3

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.732E+04	0.200E+04	0.000E+00	0.167E+03	0.148E+03	-0.106E+02
2	-0.206E+04	0.136E+04	0.000E+00	-0.129E+03	0.226E+02	0.317E+03
3	-0.180E+04	0.325E+04	0.000E+00	-0.904E+02	0.226E+02	0.317E+03
4	0.227E+04	0.312E+04	0.000E+00	0.522E+02	0.148E+03	-0.106E+02

NODE # 3

MICROSTRESSES (in psi. units) IN PLY NO.- 4 AT TIME 720.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	-0.1276E+05	SIGM11A	0.1230E+05	SIGD11B	0.2167E+04	SIGL11	0.2271E+04
3	SIGF22	-0.5466E+04	SIGM22A	0.1806E+05	SIGD22B	-0.7974E+04	SIGL22	0.3123E+04
4	SIGF12	0.3773E+03	SIGM22B	0.1664E+05	SIGD22C	0.3414E+04	SIGL33	0.0000E+00
5	SIGF23	-0.7426E+02	SIGM22C	-0.5466E+04	SIGD12B	-0.1030E+03	SIGL12	0.5223E+02
6	SIGF13	0.9809E+03	SIGM12A	0.3082E+02	SIGD12C	-0.1199E+03	SIGL23	0.1480E+03
7	SIGF33	-0.8197E+04	SIGM12B	0.5538E+02	SIGD23B	-0.1653E+02	SIGL13	-0.1056E+02
8			SIGM12C	0.6509E+02	SIGD23C	-0.1930E+02		
9			SIGM23A	-0.6733E+01	SIGD13B	0.2594E+03		
10			SIGM23B	-0.1186E+02	SIGD13C	0.3028E+03		
11			SIGM23C	-0.1384E+02	SIGD33B	-0.6456E+04		
12			SIGM13A	0.8861E+02	SIGD33C	0.5203E+04		
13			SIGM13B	0.1562E+03	SIGD11C	0.2169E+04		
14			SIGM13C	0.1825E+03				
15			SIGM33A	0.1682E+05				
16			SIGM33B	0.1434E+05				
17			SIGM33C	-0.8197E+04				
18			SIGM11B	0.1230E+05				
19			SIGM11C	0.1230E+05				

SAMPLE OUTPUT FOR PROBLEM # 13-B (Continued)

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 90 DEG. AT TOP)

FILE: UYNUMCF1 OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

TIME 780.0000000

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
12	0.258E-03	0.497E-04	0.220E-03	-0.154E-03	-0.162E-03	-0.161E-04

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 3

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.827E+04	0.336E+03	0.000E+00	0.162E+03	0.220E+03	-0.148E+02
2	-0.109E+04	-0.206E+03	0.000E+00	-0.115E+03	0.318E+02	0.472E+03
3	-0.734E+03	0.272E+04	0.000E+00	-0.679E+02	0.318E+02	0.472E+03
4	0.680E+04	0.194E+04	0.000E+00	0.207E+02	0.220E+03	-0.148E+02

NODE # 3

MICROSTRESSES (in psi. units) IN PLY NO.- 4 AT TIME 780.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	0.4844E+04	SIGM11A	0.8080E+04	SIGD11B	0.3196E+04	SIGL11	0.6797E+04
3	SIGF22	-0.2009E+04	SIGM22A	0.8901E+04	SIGD22B	-0.7471E+04	SIGL22	0.1944E+04
4	SIGF12	0.1360E+03	SIGM22B	0.9143E+04	SIGD22C	0.3461E+04	SIGL33	0.0000E+00
5	SIGF23	-0.1073E+03	SIGM22C	-0.2009E+04	SIGD12B	-0.1189E+03	SIGL12	0.2073E+02
6	SIGF13	0.1533E+04	SIGM12A	0.1240E+02	SIGD12C	-0.1378E+03	SIGL23	0.2202E+03
7	SIGF33	-0.2710E+04	SIGM12B	0.2165E+02	SIGD23B	-0.1622E+02	SIGL13	-0.1483E+02
8			SIGM12C	0.2598E+02	SIGD23C	-0.1888E+02		
9			SIGM23A	-0.9249E+01	SIGD13B	0.2717E+03		
10			SIGM23B	-0.1650E+02	SIGD13C	0.3160E+03		
11			SIGM23C	-0.1916E+02	SIGD33B	-0.5747E+04		
12			SIGM13A	0.1308E+03	SIGD33C	0.5490E+04		
13			SIGM13B	0.2330E+03	SIGD11C	0.3198E+04		
14			SIGM13C	0.2726E+03				
15			SIGM33A	0.8593E+04				
16			SIGM33B	0.8553E+04				
17			SIGM33C	-0.2710E+04				
18			SIGM11B	0.8080E+04				
19			SIGM11C	0.8080E+04				

SAMPLE OUTPUT FOR PROBLEM # 13-B (Continued)

(NOTE: PLY # 1 IS AT 90 DEG. AT BOTTOM & PLY # 4 IS AT 90 DEG. AT TOP)

FILE: UYNUMCF1 OUT A VM/SP CONVERSATIONAL MONITOR SYSTEM PAGE 00001

TIME 840.0000000

TOTAL DISPLACEMENTS FOR SELECTED NODES

NODE NO.	X (in.)	Y (in.)	Z (in.)	THETA-X (rad.)	THETA-Y (rad.)	THETA-Z (rad.)
12	-0.451E-04	-0.771E-05	0.220E-03	-0.169E-03	-0.148E-03	-0.305E-05

PLY STRESSES (in psi. units) IN THE MATERIAL COORDINATE SYSTEM FOR NODE 3

PLY NO.	SIGL-11	SIGL-22	SIGL-33	SIGL-12	SIGL-23	SIGL-31
1	-0.891E+04	-0.156E+04	0.000E+00	0.145E+03	0.299E+03	-0.184E+02
2	0.901E+02	-0.193E+04	0.000E+00	-0.907E+02	0.395E+02	0.641E+03
3	0.448E+03	0.192E+04	0.000E+00	-0.363E+02	0.395E+02	0.641E+03
4	0.117E+05	0.457E+03	0.000E+00	-0.182E+02	0.299E+03	-0.184E+02

NODE # 3
MICROSTRESSES (in psi. units) IN PLY NO. 4 AT TIME 840.0000000

NO.	STRESS	FIBER	STRESS	MATRIX	STRESS	INTERFACE	STRESS	PLY
1	NOFS	0.7000E+01	NOMS	0.1900E+02	NODS	0.1300E+02	NOLS	0.7000E+01
2	SIGF11	0.2492E+05	SIGM11A	0.2825E+04	SIGD11B	0.5000E+04	SIGL11	0.1168E+05
3	SIGF22	0.1386E+04	SIGM22A	-0.1018E+04	SIGD22B	-0.6699E+04	SIGL22	0.4575E+03
4	SIGF12	-0.2101E+03	SIGM22B	0.2459E+04	SIGD22C	0.3396E+04	SIGL33	0.0000E+00
5	SIGF23	-0.1385E+03	SIGM22C	0.1386E+04	SIGD12B	-0.1674E+03	SIGL12	-0.1818E+02
6	SIGF13	0.2230E+04	SIGM12A	-0.9795E+01	SIGD12C	-0.1925E+03	SIGL23	0.2989E+03
7	SIGF33	0.3067E+04	SIGM12B	-0.2068E+02	SIGD23B	-0.1519E+02	SIGL13	-0.1844E+02
8			SIGM12C	-0.2263E+02	SIGD23C	-0.1755E+02		
9			SIGM23A	-0.1127E+02	SIGD13B	0.3378E+03		
10			SIGM23B	-0.2034E+02	SIGD13C	0.3900E+03		
11			SIGM23C	-0.2363E+02	SIGD33B	-0.4580E+04		
12			SIGM13A	0.1759E+03	SIGD33C	0.5777E+04		
13			SIGM13B	0.3182E+03	SIGD11C	0.5003E+04		
14			SIGM13C	0.3713E+03				
15			SIGM33A	-0.1657E+03				
16			SIGM33B	0.3970E+04				
17			SIGM33C	0.3067E+04				
18			SIGM11B	0.2825E+04				
19			SIGM11C	0.2825E+04				

TIME REQUIRED TO CARRY OUT THE ANALYSIS 344.972 SEC.

TIME REQUIRED TO : READ IN DATA 0.055 SEC.
DO PREPROCESSING 0.232 SEC.

APPENDIX 1

(MATERIAL PROPERTY DATA BANK FILES)

MATERIAL PROPERTIES DATA FOR STATIC ANALYSIS
(ZERO EXPONENTS FOR SICA & TI15 MATERIALS)

```
FILE: DATAS    BANK     A1                  VM/SP CONVERSATIONAL MONITOR SYSTEM


 2
P100 ANIS 10-26-79 NO REF.
  3000 .00039
   21    5     5   30
     70.0    6600.0  1000000.       .078105000000.   900000.  1100000.   700000.
       .20      .25       .17      25.      1.74 -.0000009  .0000056  325000.0
   200000.   25000.0   25000.0   12500.0   12500.0
        .0        .0        .0        .0        .0
        .0        .0        .0        .0        .0
       .25       .25       .25       .25        .0       .25       .25       .25
       .25       .25        .0       .25       .25        .0       .25       .25
        .0       .25       .25       .25       .25       .25       .25       .25
       .25       .25       .25       .25       .25       .25
SICA    SILICON  CARBIDE  ON ALUMINUM.    SEPT. 7,1987
    1  .0056
   21     5     5   30
     70.0    4870.0  1000000.         .11 62000000. 62000000. 23800000. 23800000.
        .3        .3       .29       .75       .75  .0000018  .0000018  500000.0
   650000.  500000.0  650000.0  300000.0  300000.0
        .0        .0        .0        .0        .0
        .0        .0        .0        .0        .0
       .00       .00       .00       .00       .00       .00       .00       .00
       .00       .25       .25       .25       .00       .00       .00       .00
       .00       .00       .25       .25       .25       .25       .25       .25
       .25       .25       .25       .25       .25       .25
 2
COPR ISO  10-26-79 NO REF.
   21    13    13   30
     70.0    1980.0  1000000.         .32 17700000. 17700000.   6807692.  6807692.
        .3        .3       .09      19.3      19.3  .0000098  .0000098   32000.0
   32000.0   32000.0   32000.0   21000.0   21000.0
        .0        .0        .0        .0        .0        .0        .0        .0
        .0        .0        .0        .0        .0
        .0        .0        .0        .0        .0        .0        .0        .0
        .0        .0        .0        .0        .0
        .5        4.        .5        .5        .0        .5        .5        .5
        .5        .5        .0        .5        .5        .0        .5        .5
        .0        .5        .5        .5        .5        .5        .5        .5
        .5        .5        .5        .5        .5        .5
TI15     TITANIUM  ALUMNM.                       NOV. 9,1987.
   21    13    13   30
     70.0    1800.0  1000000.        .172 12300000. 12300000.   4659091.  4659091.
       .32       .32       .12       .39       .39  .0000045  .0000045  130000.0
  130000.0  130000.0  130000.0   91000.0   91000.0_
        .0        .0        .0        .0        .0        .0        .0        .0
        .0        .0        .0        .0        .0
        .0        .0        .0        .0        .0         0        .0        .0
        .0        .0        .0        .0        .0
        .0        .0        .0        .0        .0        .0        .0        .0
        .0        .5        .5        .5        .0        .0        .0        .0
        .0        .0        .5        .5        .5        .5        .5        .5
        .5        .5        .5        .5        .5        .5
```

MATERIAL PROPERTIES DATA FOR STATIC ANALYSIS (CONTINUED)
(ZERO EXPONENTS FOR SICA & TI15 MATERIALS)

```
FILE: DATAS    BANK    A1                VM/SP CONVERSATIONAL MONITOR SYSTEM

 2
P100/COPR 10-26-79 NO REF.
   21    9    9   30
      70.0    4290.0  1000000.       .199 61350000.  9300000.  3404396.  3404196.
       .25      .275      .155      13.4     10.52  .0000045  .0000105  341000.0
  116000.0   41000.0   28500.0   22000.0   15750.0
        .0        .0        .0        .0        .0        .0        .0        .0
        .0
        .0        .0        .0        .0        .0        .0        .0        .0
        .0
        .5        2.        .5        .5        .0        .5        .5        .5
        .5        .5        .0        .5        .5        .0        .5        .5
        .0        .5        .5        .5        .5        .5        .5        .5
        .5        .5        .5        .5        .5        .5
SICA/TI15 10-26-79 NO REF.
   21    9    9   30
      70.0    3335.0  1000000.       .141 37150000. 37150000. 14229546. 14229456.
       .31       .31      .205       .57       .57  .0000032  .0000032  315000.0
  390000.0  315000.0  390000.0  195500.0  195500.0
        .0        .0        .0        .0        .0        .0        .0        .0
        .0
        .0        .0        .0        .0        .0        .0        .0        .0
        .0
        .5        .5        .5        .5        .0        .5        .5        .5
        .5        .5        .5        .5        .5        .5        .5        .5
        .5        .5        .5        .5        .5        .5        .5        .5
        .5        .5        .5        .5        .5        .5
       70.        1.        1.        1.        1.        70000.
/EOF
```

MATERIAL PROPERTIES DATA FOR NONLINEAR ANALYSIS
(NONZERO EXPONENTS)

```
FILE: DATA     BANK     A1                 VM/SP CONVERSATIONAL MONITOR SYSTEM


 2
P100 ANIS 10-26-79 NO REF.
  3000 .00039
   21     5     5   30
     70.0    6600.0  1000000.      .078105000000.   900000.  1100000.   700000.
      .20       .25       .17       25.      1.74 -.0000009  .0000056  325000.0
   200000.   25000.0   25000.0   12500.0   12500.0
       .0        .0        .0        .0        .0
       .0        .0        .0        .0        .0
      .25       .25       .25       .25        .0       .25       .25       .25
      .25       .25        .0       .25       .25        .0       .25       .25
       .0       .25       .25       .25       .25       .25       .25       .25
      .25       .25       .25       .25       .25       .25
SICA    SILICON  CARBIDE  ON ALUMINUM.    SEPT. 7,1987
    1  .0056
   21     5     5   30
     70.0    4870.0  1000000.       .11 62000000. 62000000. 23800000. 23800000.
       .3        .3       .29       .75       .75  .0000018  .0000018  500000.0
   650000.  500000.0  650000.0  300000.0  300000.0
       .0        .0        .0        .0        .0
       .0        .0        .0        .0        .0
      .25       .25       .25       .25       .00       .25       .25       .25
      .25       .25       .25       .25       .25       .00       .25       .25
      .00       .25       .25       .25       .25       .25       .25       .25
      .25       .25       .25       .25       .25       .25
 2
COPR ISO  10-26-79 NO REF.
   21    13    13   30
     70.0    1980.0  1000000.       .32 17700000. 17700000.  6807692.  6807692.
       .3        .3       .09      19.3      19.3  .0000098  .0000098   32000.0
   32000.0   32000.0   32000.0   21000.0   21000.0
       .0        .0        .0        .0        .0        .0        .0        .0
       .0        .0        .0        .0        .0
       .0        .0        .0        .0        .0        .0        .0        .0
       .0        .0        .0        .0        .0
       .5        4.        .5        .5        .0        .5        .5        .5
       .5        .5        .0        .5        .5        .0        .5        .5
       .0        .5        .5        .5        .5        .5        .5        .5
       .5        .5        .5        .5        .5        .5
TI15    TITANIUM  ALUMNM.                 NOV. 9,1987.
   21    13    13   30
     70.0    1800.0  1000000.      .172 12300000. 12300000.  4659091.  4659091.
      .32       .32       .12       .39       .39  .0000045  .0000045  130000.0
  130000.0  130000.0  130000.0   91000.0   91000.0
       .0        .0        .0        .0        .0        .0        .0        .0
       .0        .0        .0        .0        .0
       .0        .0        .0        .0        .0        .0        .0        .0
       .0        .0        .0        .0        .0
       .5        .5        .5        .5        .0        .5        .5        .5
       .5        .5        .5        .5        .5        .0        .5        .5
       .0        .5        .5        .5        .5        .5        .5        .5
       .5        .5        .5        .5        .5        .5
```

MATERIAL PROPERTIES DATA FOR NONLINEAR ANALYSIS (CONTINUED)
(NONZERO EXPONENTS)

```
FILE: DATA     BANK     A1               VM/SP CONVERSATIONAL MONITOR SYSTEM


 2
P100/COPR 10-26-79 NO REF.
   21    9     9   30
      70.0     4290.0  1000000.      .199 61350000.  9300000.  3404396.  3404196.
       .25       .275      .155      13.4     10.52  .0000045  .0000105  341000.0
  116000.0    41000.0   28500.0   22000.0   15750.0
        .0         .0        .0        .0        .0        .0        .0        .0
        .0
        .0         .0        .0        .0        .0        .0        .0        .0
        .0
        .5         2.        .5        .5        .0        .5        .5        .5
        .5         .5        .0        .5        .5        .0        .5        .5
        .0         .5        .5        .5        .5        .5        .5        .5
        .5         .5        .5        .5        .5        .5
SICA/TI15 10-26-79 NO REF.
   21    9     9   30
      70.0     3335.0  1000000.      .141 37150000. 37150000. 14229546. 14229456.
       .31        .31      .205       .57       .57  .0000032  .0000032  315000.0
  390000.0   315000.0  390000.0  195500.0  195500.0
        .0         .0        .0        .0        .0        .0        .0        .0
        .0
        .0         .0        .0        .0        .0        .0        .0        .0
        .0
        .5         .5        .5        .5        .0        .5        .5        .5
        .5         .5        .5        .5        .5        .5        .5        .5
        .5         .5        .5        .5        .5        .5        .5        .5
        .5         .5        .5        .5        .5        .5
       70.         1.        1.        1.        1.        70000.
/EOF
```

APPENDIX 2

(HITCAN EXECUTION FILES)

FILE FOR HITCAN EXECUTION ON NASA LERC CRAY-XMP
(fill in the appropriate filename & filetype for the problem to be run. Also, use the appropriate name for data bank file.)

```
FILE: DEMOX    NQS      A1                  VM/SP CONVERSATIONAL MONITOR


# USER=smxxxx PW=xxxxxxxx
# QSUB-r filename
# QSUB -lT 60
# QSUB -lM 2.0Mw
# QSUB-eo
set -x
 fetch data -t'fn=filename,ft=filetype'             # input file
#fetch restar -t'fn=filename,ft=restart'        # restart file
#cat restar >>data
touch t7 t8 t10 t11 t12 t18 t19 t50 t54 t70
touch t57 t59 t61 t63 t66 t67 t68 t76 t77 t78 t79 t93 t95 t96
ln t6 fort.6
ln t7 fort.7
ln t8 fort.8
ln t10 fort.10
ln t11 fort.11
ln t12 fort.12
ln t18 fort.18
ln t19 fort.19
ln t50 fort.50
ln t54 fort.54
ln t57 fort.57
ln t59 fort.59
ln t61 fort.61
ln t63 fort.63
ln t66 fort.66
ln t67 fort.67
ln t68 fort.68
ln t70 fort.70
ln t76 fort.76
ln t77 fort.77
ln t78 fort.78
ln t79 fort.79
ln t93 fort.93
ln t95 fort.95
ln t96 fort.96
fetch t70 -t'fn=data,ft=bank'                  # data bank
jad
$HOME/htcan < data# compiled code
jar -a
#dispose t18 -t'fn=filename,ft=model'
#dispose t77 -t'fn=tran,ft=file'
dispose t68 -t'fn=filename,ft=restart'
#dispose t76 -t'fn=filename,ft=disp'
#dispose t93 -t'fn=for,ft=file'
#dispose t66 -t'fn=met,ft=file'
#dispose t50 -t'fn=t50,ft=file'
rm core fort* tmp* data t*
exit
```

FILE FOR HITCAN EXECUTION ON NASA LERC CRAY-YMP
(fill in the appropriate filename & filetype for the problem to be run. Also, use the appropriate name for data bank file.)

```
FILE: DEMOY    NQS      A1                VM/SP CONVERSATIONAL MONITOR

# QSUB-r filename
# QSUB -lT 100
# QSUB -lM 2.0Mw
# QSUB-eo
cd $W
set -x
#cat restar >>data
touch t7 t8 t10 t11 t12 t18 t19 t50 t54 t70
touch t57 t59 t61 t63 t66 t67 t68 t76 t77 t78 t79 t93 t95 t96
ln t6 fort.6
ln t7 fort.7
ln t8 fort.8
ln t10 fort.10
ln t11 fort.11
ln t12 fort.12
ln t18 fort.18
ln t19 fort.19
ln t50 fort.50
ln t54 fort.54
ln t57 fort.57
ln t59 fort.59
ln t61 fort.61
ln t63 fort.63
ln t66 fort.66
ln t67 fort.67
ln t68 fort.68
ln t70 fort.70
ln t76 fort.76
ln t77 fort.77
ln t78 fort.78
ln t79 fort.79
ln t93 fort.93
ln t95 fort.95
ln t96 fort.96
cp $HOME/data.bank t70# data bank
jad
#$HOME/htcan < data
htcan < filename.filetype
jar -a
cp t18 patran.beam
rm core fort* tmp* data t*
exit
```

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2. Singhal, S. N., Lackney, J. J., Chamis, C. C., and Murthy, P. L. N., "Demonstration of Capabilities of High Temperature Composites Analyzer Code HITCAN", NASA TM-102560, 1990.

3. Lackney, J. J., Singhal, S. N., Chamis, C. C., and Murthy, P. L. N., "HITCAN: High Temperature Composite Analyzer-USER's Manual", March, 1992.

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S.N. Singhal, J.J. Lackney, and P.L.N. Murthy

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Sverdrup Technology, Inc.
Lewis Research Center Group
2001 Aerospace Parkway
Brook Park, Ohio 44142

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12a. DISTRIBUTION/AVAILABILITY STATEMENT

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12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 words)***

This manual comprises a variety of demonstration cases for the HITCAN (HIgh Temperature Composite ANalyzer) code. HITCAN is a general purpose computer program for predicting nonlinear global structural and local stress-strain response of arbitrarily oriented, multilayered high temperature metal matrix composite structures. HITCAN is written in FORTRAN 77 computer language and has been configured and executed on the NASA Lewis Research Center CRAY XMP and YMP computers. Detailed description of all program variables and terms used in this manual may be found in the USER's MANUAL. The demonstration manual includes various cases to illustrate the features and analysis capabilities of the HITCAN computer code. These cases include: 1) static analysis, 2) nonlinear quasi-static (incremental) analysis, 3) modal analysis, 4) buckling analysis, 5) fiber degradation effects, 6) fabrication-induced stresses for a variety of structures; namely, beam, plate, ring, shell, and built-up structures. A brief discussion of each demonstration case with the associated input data file is provided. Sample results taken from the actual computer output are also included.

14. SUBJECT TERMS

Metal matrix composite structures; Fiber composites; Composite mechanics; Laminate analysis; Micro stresses; Micromechanics; High temperature; Thermal properties; Material non-linearities; 2D and 3D nonlinear analysis; Finite elements; Buckling; Stress analysis; Vibrations

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